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Contents.

	PAGE
The Passing of Long-held Fancies	150
The Institute of Metals	152
Mr. F. J. Cook's New Activities	152
Correspondence	152
Foundry Queries	152
Some Notes on Refractory Materials	153
The "Silacene" Competition Result	154
The Structural Composition of Cast Iron	155
A New Aluminium Alloy-Alpax	161
Melting White Bearing Alloys	165
Institute of British Foundrymen	166
Condition of the British Iron and Steel Industry	168
Trade Talk	170
Iron and Steel Markets	172

Forthcoming Events.

FEBRUARY 20.

Institute of British Foundrymen (Sheffield Branch):—Ordinary meeting at Sheffield.

Junior Institution of Engineers:—Lecturette, "Inverted Tooth Chain Drives," by J. Seddon.

Institution of Production Engineers:—General meeting in London. "Grinding Practice," Paper by H. A. Dean

Midland Institute of Mining Engineers:—General meeting at Sheffield. "Manufacture of Coke Oven Coke," Paper by Dr. E. W. Smith and F. S. Townsend, B.Sc.

West of Scotland Iron and Steel Institute:—Ordinary meeting at Glasgow. "Basic Steel Practice," Paper by Dr. Thomas Swinden.

FEBRUARY 21.

Institute of British Foundrymen (West Riding of Yorkshire Branch):—Ordinary meeting at Wakefield. "Cupola Practice." Paper by J. Wood.

Stoke-on-Trent Association of Engineers:—Annual dinner at Stoke-on-Trent.

FEBRUARY 23.

Sheffield Society of Engineers and Metallurgists:—Ordinary meeting at Sheffield. "Gas Furnaces applied to the Steel Industry," Paper by S. A. Sears, B.Sc.

Royal Society of Arts:—Cantor Lecture (II) in London. "The Inner Structure of Alloys," by Walter Rosenhain, B.A., F.R.S.

FEBRUARY 24.

Institution of Engineers and Shipbuilders in Scotland:—General meeting at Glasgow. "The Latest Type of the Burmeister and Wain Marine Diesel Engine," Paper by H. H. Blache of Copenhagen.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

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The Passing of Long-held Fancies.

Foundrymen generally are still utilising theories which were evolved many years ago, and some of which have since been shown to be wrong. In most branches of science, especially medicine, it has been found that a new remedy is for a time most efficient, but afterwards this decreases, and finally it becomes almost useless. Usually, by this time, a new specific has been brought into being. Cast iron is no exception. Years ago, some worthy scientist insisted that metals crytallised at right angles to the cooling surface, and therefore at the corners of box-like castings there was a diagonal line, which was weak. Rosenhain has pointed out that, except in the case where they are separated from one another by films of brittle material, intercrystalline boundaries are planes of strength rather than of weakness. Dr. Johnson has explained that stresses are left in castings where a thin and more rapidly cooled section would pull from the thicker section. Additionally there may be found a small shrinkage cavity to aggravate the stressed condition of casting. Mr. F. C. Edwards, probably remembering the old story of the Royal Society, the bowl full of water, the added fish, and the non-spilling of the water, has tested practically the intercrystalline diagonal plane of weakness between sections meeting at right angles, and he confirms its non-existence.

Another fallacy, in which foundrymen have had implicit faith for many years, is that an egg cup full of drillings taken from any position of a grey iron casting, when analysed gives him figures on which he can rely. We would remind such people that it is quite a simple matter to have a fin on a soft, large-sectioned, grey-iron casting which is undrillable. The chemical compositions, so far as essentials are concerned, of the boss and the tip of a cast-iron propeller blade are quite different. The former is characteristic of a soft iron, and the latter of a hard one, as revealed in the constitution of the combined carbon.

Whilst this is a fundamental principle it is still more or less overshadowed by the quantity and distribution of the graphite. Because silicon is a factor in the control of the graphite, it has been allowed to supersede it in importance in the minds of many responsible for handling cast iron.

It is thus clear that proper sampling of a casting becomes of paramount importance, and any test piece cast for the purpose of analysis does not so far as the prime constitution even represent the metal either in the ladle or casting. In the ladle, of course, all the carbon is combined, whilst in the casting the amount in the combined form depends upon the cooling conditions to which it is subjected. To ascertain the quantity of the two varieties of carbon in any type of casting, every section must be drilled and mixed in accordance with the weight of that section.

Mr. Logan's Paper, "The Structural Composition of Cast Iron," printed elsewhere in this issue, should be studied by all foundrymen, as it gives a very clear picture of the real constitution of cast iron. It puts the various factors controlling cast iron into the proper perspective, and dispels some more long-held fancies.

Another mistaken idea which is passing is that the manufacture of simple heavy castings at a small loss helps to reduce overhead charges and enables a profit to be shown on the ordinary run of work. It is particularly gratifying to us to learn that one important district Foundry Owners' Association is giving close attention to the question of the installation in their district of a unified costing system.

The Institute of Metals.

ANNUAL GENERAL MEETING.

As previously announced, the annual general meeting of the Institute of Metals will be held, by kind permission, in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, on March 11 and 12, 1925. The meetings will commence at 10 a.m. each day, concluding not later than 4 p.m. On March 11 the annual dinner of the Institute will be held at the Trocadero Restaurant, Piccadilly Circus, W.1, at 7.30 p.m.

Papers to be Submitted.

The following communications are expected to be submitted:—"The Effect of Grain-Size upon Hardness and Annealing Temperature," by H. T. Angus, M.Sc., and P. F. Summers, A.R.S.M.; "A Method of Improving the Properties of Aluminimum Alloy Castings," by S. L. Archbutt, F.I.C.; "The Density and Constitution of the Industrial Brasses," by G. L. Bailey, M.Sc., and R. Genders, M.Met.; "Compafative Tests on Some Varieties of Commercial Copper Rod," by T. G. Bamford, M.Sc.; "The Removal of Red Stains from Brass," by E. A. Bolton, M.Sc.; "The Influence of Lead and Tin on the Brittle Ranges of Brass," by Denis Bunting, M.Sc.; "Surface Abrasion as a Potential Cause of Localised Corrosion," by Ulick R. Evans, M.A.; "The Influence of Emulsoids upon the Rate of Dissolution of Zinc in Solutions of Lead, Nickel and Copper Salts," by J. Newton Friend, D.Sc., and J. S. Tidmus, M.Sc.; "The Alpha Phase Boundary in the Copper-Zinc System," by R. Genders, M.B.E., and G. L. Bailey, M.Sc.; "Some Experiments on the Abrasion of Metals," by Professor Kotaro Honda, Sc.D., and Professor Ryónosuke Yamada; "On the Equilibrium Diagram of the Aluminium-Zinc System," by Professor Timimatu Isihara; "Note on the Effects of Certain Elements on the Electrical Resistivity of Copper," by A. L. Norbury, M.Sc.; and "On the Density of Rhodium," by Sir Thomas Kirke Rose, D.Sc., A.R.S.M.

May Lecture.

Professor Dr. H. A. Lorentz, Professor of Physics at the University of Leiden, Holland, will deliver the annual May lecture on May 6, 1925, his subject being "The Motion of Electricity in Metals."

The Annual Dinner.

Among those who have already accepted the invitation of the Council to be present at the dinner as guests of the Institute are the following:—The Right Hon. Neville Chamberlain, P.C., M.P. (Minister of Health), and Mrs. Chamberlain; the Right Hon. the Lord Morris, P.C., K.C.M.G., LL.D., D.C.L., K.C. (Vice-Chairman, Imperial Mineral Resources Bureau); Sir John Cadman, K.C.M.G., D.Sc.; Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S. (Rector, Imperial College of Science and Technology); Colonel R. A. Johnson, C.B.E., T.D. (Deputy Master, the Royal Mint); Sir Joseph Petavel, K.B.E., D.Sc., F.R.S. (Director, the National Physical Laboratory); Mr. R. O. Patterson (President of the Institute of British Foundrymen); and the presidents, chairmen and secretaries of allied bodies and societies.

New Members and the London Meeting.

A special Council meeting will be held in London on February 25 for the purpose of considering applications for membership. Those applicants for membership whose forms are in the secretary's hands before noon on February 25 will be entitled to take part in all the proceedings at the London meeting. Subscriptions of members elected as a result of the forthcoming ballot cover the extended period ending June 30, 1926. Further, they will be entitled to receive a free copy of the Journal that is to be published in June at 31s. 6d. (price to non-members), in addition to (free) volumes to be published at the same price in December, 1925, and June, 1926. The necessary membership forms and booklets will be sent upon application to the Secretary, Mr. G. Shaw Scott, 36, Victoria Street, London, S.W.1.

National Light Castings Association.

The National Light Castings Association are again receiving attention by the daily Press on account of their proposal to raise the price of builders' castings. It is stated in one paper that they cover 95 per cent. of the industry. This we do not believe. The condition of this trade in 1913 was so poor that only a very few foundries could afford to modernise, and whatever objections may be brought against the Association, there will always remain the outstanding feature that it has raised the whole condition and status of the trade. It has enabled members to improve their buildings and plant, and to render them in a better condition to meet any foreign competition in both the home and foreign markets. In this connection we would draw attention to the table on page 17, which give the exports of some castings for January. The Board of Trade have itemised the figures for the first time.

Mr. F. J. Cook's New Activities.

Mr. F. J. Cook, M.I.Mech.E., Past-President of the Institute of British Foundrymen, has resigned his position of managing director of Messrs. Rudge Littley, Limited, of Swan Village, West Bromwich, but still retains his seat on the directorate. Being thus more free, Mr. Cook has associated himself with Mr. W. O'Keefe as sales director to the Adaptable Moulding Machine Company, of Sydney Works, Stanhope Street, Birmingham. We are pleased to learn that his new business associations will allow him to devote more time to technical society work, and both the Institute of British Foundrymen and the British Cast Iron Research Association will be happy to claim a larger share of his time.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Designing a 4-ton Cupola.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have read with interest the letter in your last issue from "Worried," and may say I have for some time been using a material for jointing brickwork which has completely overcome my previous difficulties in a similar direction to those mentioned by him.

A small piece of the paste is enclosed herewith. This has only been dried by the atmosphere, but is still exceptionally hard. This is how it sets between the bricks, and if "Worried" cares to write me at the address below I shall be happy to put him in touch with the firm who produce it.

Yours, etc.,

HENRY J. WILLIAMS.

205, Carlton Road, Worksop, Notts.

Foundry Queries.

Surface on Grey Iron Castings.

We produce a small quantity of light grey iron castings for electrical work; the section varies from ¼ in. to 3/16 in., and are having much trouble by defacement, which we believe is primarily due to the coal dust. We are using Stourbridge sand. Can you advise us how to get the excellent skin such as is found on the castings from the Black Country, particularly from Messrs. Harpers, of Willenhall?—"ELECTRICAL."

Grain Refining of Grey Cast Iron.

Can any of your readers give me any information as to the (grain) closing of grey iron castings by means of fluxes or other methods? The castings referred to are of heavy section weighing between 3 to 15 cwt. each, and have to withstand a high hydraulic pressure.—J. H.

Altrincham, February 12, 1925.

AT A MEETING of the Scottish Section of the Institute of Metals, Mr. J. A. Gardiner delivered an address on "Methods of Keeping Foundry Records." Mr. J. Stirling presided.

Some Notes on Refractory Materials.*

By Vincent C. Faulkner.

The introduction of cupro-nickel and other alloys with high melting points has caused the non-ferrous foundryman to take a closer interest in refractory materials. Generally speaking, on account of the variations in the cost of their expensive raw materials, but little attention has been devoted to "melting costs" in non-ferrous foundry work. It is well known that careful or careless buying of metals gives figures in the books of the concern which overshadow any possible extravagances or economics that the commonsense application of refractories could possibly show.

It will be assumed that the experience gained on high temperature furnaces, such as electric steel melting plant will be applicable to those demanding somewhat less rigid conditions. That is, a man capable of economically running a steel furnace should have but little difficulty in getting good results from, say, a reverberatory for melting manganese bronze, or the lining of a crucible furnace.

Preliminary Considerations.

A number of types of refractory materials are available in the form of bricks, special shapes, powders, grains and cements. Dealing with the bricks first, these are available as firebricks, silicas, magnesites, chrome, bauxite and carbon. As a general desideratum, it should be insisted that all bricks should conform to specified dimensional limits, as it has been shown elsewhere that for at least for firebricks there is a very considerable departure from standard dimensions, and the author's experience not only confirms this but extends it to embrace most other types of brick. Magnesite bricks are, perhaps, the truest to shape of all. The conformity to dimensional standards is imperative because, generally speaking, the cementing material is never as good as the brick, and poor shape necessitates the use of larger quantities of cement.

The chemical control of bricks is desirable, though the interpretation of the results obtained is often difficult because the commonly accepted deductions fail to agree with practice.

Physical tests, especially the heat-conductivity, are of the most profound importance, and from experience it is felt that the results would more or less align themselves with the grain size. The smaller the grain size the better the heat conductivity. If the exposed surface has to resist the whole of the applied heat and is incapable of passing any of it backwards, it is liable to fail.

Expansion and contraction are other properties which should be available for the man in charge of furnace operations. They can indicate, in the case of silicas, that the brick has not been burnt at sufficiently high temperature, which, by the way, is a very common fault in British practice. The laboratory should also indicate the amount which must be allowed for expansion. The imposition of pressure on most types of bricks lowers their fusing point and certainly makes them more chemically active to materials on the other side of the resultant compound. Obviously, to ensure that bricks are all under equal pressure they must be free from warping, hollows and swellings. If they are excessive they can cause cracking. Any steps which can be taken to avoid even "deadweight leading" should be adopted. In furnaces of the box type, the roof should never rest on the side walls, but on the iron work of the furnace, whilst for shaft furnaces angles should periodically be inserted to take the weight.

It is thus strongly recommended that if it is found impossible to obtain dimensionally-correct bricks from the suppliers, they should be ground to size. It may be objected that this is ridiculous on the score of cost. If the furnace has to withstand really high temperatures and an extra few days' life is obtained it is worth while. It is suggested that if a furnace wall is built correctly of known materials heated in the way to be described, it may be possible to use cheaper materials. By "grinding" to size it is not meant that they should receive machine-shop treatment, but it should be accomplished by hand-rubbing with a harder type of brick. A carborandum brick is ideal for this purpose. It is insisted that no rocking or rolling must ever be permitted.

If a suitable and reliable bonding material can be found it is preferable to use this rather than setting dry, whilst if the brickwork has been well built this can and should be kept to a minimum. Mechanically, which also means physically, a better bearing is given, which enables a more even distribution of stresses. A rider to this indicates that it is desirable to incorporate "specials" where much cutting is involved. Unfortunately, the author's experience shows that it is rare to find specials possessing as good qualities as standard shapes. The expansion of the brickwork, both horizontally and vertically, should be allowed for, vertically by leaving a space between the wall and the roof, or next angle-iron support, and horizontally by leaving a rectangular slit.

A space varying in width from ½ to 1 in., according to the size of the furnace, should be left between the outer casing and the wall. This is preferably filled with brickbats and Kieselguhr. Whilst it is desirable that heat should be passed to the back of the wall in order to cut down the work to be exacted from the face of the brick, it is imperative that insulation should be effective here, and perhaps the best known insulator is imprisoned stationary air. Kieselguhr is an ideal means for accomplishing this.

It has been found that when brickwork has been "glazed," or, in other words, when it presents a minimum of surface, it is the most efficient. In this condition it probably deals with heat and light rays by reflecting them back instead of absorbing them. To help the brickwork to get into this condition it is suggested that it should be plastered with a refractory coating. These plastered refractories should be applied in preferably two coats, each of about ¼ of an inch thick, and air-dried over-night in each case.

Plastic Refractories.

A physical survey of plastic refractories reveals some features of more than ordinary interest for the metallurgist. Primarily, it is under no appreciable pressure, and therefore does not have its melting point lowered from this cause. Again, there is probably a large content of imprisoned air which will render it a poor conductor, and lessens the work for the actual wall. Having a much greater initial surface area than bricks, being merely an aggregation of small particles, mechanically mixed, they readily, at first, absorb all rays and quickly vitrify when they begin to reverse conditions, and reflect all rays.

Cupolas, crucible holes, the port-blocks of open-hearth, and furnace doors are regularly but not universally constructed of granulated or plastic refractories with varying results. When a full wall is built a complaint often heard is that they glaze beautifully on the exposed surface, but once this is broken it exposes a powdery, unbonded interior. This is obviously a case, which breaks the fundamental principle previously outlined, that is, the material is incapable of passing a certain amount of the applied heat to the interior owing to the non-intimate character of the mixture. Inadvertently, perhaps, three remedies are practised. The oldest one is the bolting on of large-sized angle-irons to the iron casing, which, of course, increases the average conductivity of the mass; the second incorporates the use of brickbats, whilst the third utilises a system of excessive venting, which obviously provides a path for the entrance of hot gases. None of these, however, fills the bill. The problem is not distantly related to that of the construction of an electrically-conductive furnace hearth. This problem has been satisfactorily solved in Great Britain, France, Spain, and Italy, but a careful perusal of German and American literature seems to indicate, that neither of these coun-

* A Paper read before the Institute of Metals (London Section), Dr. J. L. Haughton presiding.

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tries has ever quite found a satisfactory solution. A refractory only needs to be excellent at the "business" surface, the rest requires to be workmanlike. Primarily, plastic refractories are good, because never being under real pressure, they maintain their original melting points. They are bad, because of their inability to disperse just that amount of heat which is the difference between success and failure. The three remedies outlined are puerile, and the author feels confident that infinitely better results would be achieved by intimately mixing with materials such as carbon (retort or graphite), chrome ore, steel turnings and the like. Plastic refractories are quite good conductors until the steam is driven off, after which they need some help such as has been indicated.

Another disadvantage of most plastic refractories is that they have a considerable contraction on drying, which necessitates placing-in-position in layers, and allowing to air-dry. It should be possible to construct the walls of furnaces entirely of plastic refractories, in fact, it is regularly accomplished in cupola practice; but this same material when used for furnace doors requires to be built up in layers. For rectangular furnaces it is suggested that cracking would be serious, especially at the corners. If amongst the clay-silica sand percentages, there can be found a mixture that does not contract on air-drying and subsequent baking, it should find much use for replacing brickwork in reverberatory and other furnaces. Pure silica sand, plus a minimum addition of china clay, would appear to furnish the best base for practical research.

Roofs.

Many types of furnaces carry an arched roof. Two types exist—a "saddle-back" for rectangular furnaces and a "beehive" for circular ones. For the saddle-back it is insisted that the construction should be of a series of independent arches, and not be bonded. This allows each arch to take up its own expansion and evenly to distribute the stresses. It is usual to insert either thin pieces of 9 × 4½ in. wood or cardboard to take care of the expansion. Beehive roofs demand special shapes. Mechanically they are stronger, but the prevention of local overloading is difficult, and the introduction of combustible material to take up the expansion is usually a matter of guesswork. Cementing material is seldom used, as it invariably reduces the "life" of the roof. Sometimes, with the object of filling interstices, a silica cement is washed over the convex surface—a process liable to cause spalling. Often silica brick chippings, which may or may not be clean, are brushed over. None of these is of any real use, nor would be an attempt to coat the inner surface with a plastic refractory, as the movements during drying would cause it to spall off.

Mixing Refractories.

Considering that a breakdown in refractories usually involves much more serious losses than mere cost of replacement, every small detail is worthy of serious attention. The author quite recently saw in one of Germany's most modern steel foundries the preparation of a dolomite and tar mixture for an electric furnace hearth. The dolomite was being heated on a steel plate, supported at its corners by temporary brickwork piers, and the mixing with the hot tar was accomplished much in the same way as an Irish labourer prepares the mortar for the bricklayer. The best practice demands a proper stove and a clean pug mill, especially for conducting hearths, as an excess of tar in one spot will cause too much current to pass through a restricted and badly-made path with possibly disastrous results. These hearths are constructed in distinct layers, usually about five—that next to the source of heat being pure dolomite, whilst the one furthest removed may contain as much as 25 per cent. of extraneous matter, such as iron filings, carbon, horse-shoe nails, chrome ore. Additionally steel spikes connect the lower portion of the topmost layer to the bottom layer of pure carbon. The quantity of tar used can be standardised as the amount required completely to blacken the greyish white dolomite. The dolomite should be free from powder. This type of hearth, on which several thousands of heats have been made, embodies the principle enunciated, that the "business" surface should be a high-class refractory, but the backing should be a material of higher conductivity capable of relatively cooling it. This principle is further exemplified by the wonderful "life" often experienced from an open-hearth furnace roof when it has been worn down to a thickness of, say, 4 ins. Cooling is actively operating, and the weight-load has been diminished. If a basic furnace carries an acid roof, it is advisable periodically to "dust" it by means of a compressed-air jet. The quantity of lime dust can assume serious proportions, whilst the vibrations emanating from overhead cranes and other machinery allows it to reach the underside, through the brick joints.

In theory, acid bricks should never be in direct contact with silicas, it usually being recommended that a layer of neutral chrome bricks be used to separate them. This may be true of a 50-ton open-hearth furnace, when pressure is such an important factor, but for small basic furnaces where there are perhaps but six rows of silicas above it, fluxing action is seldom apparent. Only once has the author found fluxing taking place, and that was between the Grecian (or pure) magnesite and not the Austrian or ferruginous type. The great disadvantage of magnesite bricks is, or was, the inability to purchase these in form other than plain squares. This often involved cutting to waste bricks which, in war days, cost 1s. 6d. each.

The "Silacene" Competition Result.

We have had an opportunity of inspecting the entries submitted in connection with the competition organised by Messrs. T. H. Gray and Company, Limited, of 119, High Holborn, London, W.C.1. The competition has been won by Mr. H. J. Young, F.I.C., chief metallurgist, Messrs. The North Eastern Marine Engineering Company, Limited, of Wallsend-on-Tyne. The second prize has gone to Mr. F. J. Cree, foundry manager to Messrs. Barford and Perkins, Limited, of Peterborough, whilst the two third prizes are divided between Mr. David Whyte, of 8, Vale View, Porthill, Stoke-on-Trent and Mr. J. Worley, foreman bricklayer, Consett Iron Company, Limited.

The number of enquiries about the competition was large, but the actual number of entries small. This is readily understandable when a personal attempt is made to work out an interesting advertisement. The method used both by Mr. Young and Mr. Cree was to tell a reasonably constructive story.

H. Stockwell and Company, of 10, Corporation Street, Manchester, have been appointed by Evrard Havenith, of Antwerp and London, as their sole British selling agents for semi-finished metallurgical products, including basic and foundry pig-iron, steel ingots, blooms, slabs, billets, sheet bars, tube strips, wire rods in Siemens-Martin steel, basis steel, and all other types usually exported from the Continent of Europe to Great Britain.

Catalogue Received.

Foundry Equipment.—The Constructional Engineering Company, Limited, of Titan Works, Charles Henry Street, Birmingham, are circularising the foundry trades with an eight-page brochure which in an interesting way describes and illustrates the Titan Cupolette. It also contains a lay-out for a small foundry, which though quite good, could perhaps be improved by reversing the positions shown for the "shaking barrel" and the "motor and engine room," and continuing the lean-to so as to include an inspection and despatch department. Altogether, the catalogue is a very interesting production.

MR. FRANK RUSSELL, F.G.S., F.E.S., managing director of the General Refractories Company, Limited, of Sheffield, was the speaker at one of the series of evening meetings organised by the Sheffield Free Libraries Committee. The subject of the lecture was "The Story of the Rocks," and Mr. Russell endeavoured in the short space of time at his disposal to sum up in simple language the natural means by which the crust of the earth had been formed, with particular refernec to the rocks in and around Sheffield.

The Structural Composition of Cast Iron.*

By Arthur Logan, M.Inst.Brit.F.

Two years ago Mr. C. Gresty, in a Paper entitled the "Examination and Photography of Cast Iron under the Microscope,"† stated: "Nowadays most metallurgical Papers are illustrated by photo-micrographs, and it is probable that the average foundryman, not being a trained metallurgist, would more fully appreciate and understand the illustrations if he were familiar with the methods by which they are obtained. The object of the Paper is to describe practical microscopic work as applied to cast iron, and to show how the various constituents of the metal may be distinguished. *It is not proposed to deal with the theoretical side of the constitution of cast iron. . . .*"

The objects of the Paper as set forth in the introductory remarks just quoted were admirably achieved. The Paper is a clear and concise account of the photo-micrography of cast iron; but obviously, treating the subject in a comprehensive manner, it was impossible to deal with the theoretical constitution of cast iron. It has always seemed to the present author, therefore, that if a further chapter could be added dealing with this side of the subject in a simple way, then the foundryman would be in a much better position to understand and appreciate something of the subtleties of this complex material.

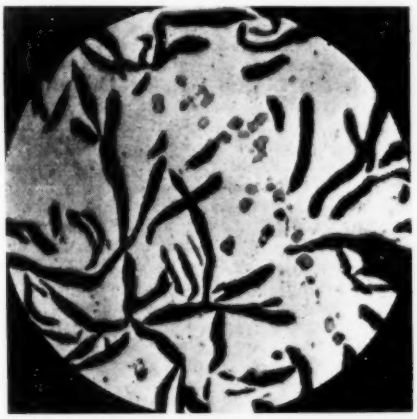


FIG. 1.—UNETCHED MICRO OF CAST IRON SHOWING GRAPHITE AND MANGANESE SULPHIDE.

This, then, is the justification for the following Paper, "The Structural Composition of Cast Iron," which is to be regarded as being in some degree a second chapter of the first-mentioned Paper. The object of this second portion, to express it in a single sentence, is to enable the foundryman to understand why slight differences of chemical composition can have so large an influence on the iron. The foundryman may think that the structural composition of cast iron is not his concern, but it is. It is the vital concern of every foundryman, consciously or unconsciously. Everyone who mixes iron, whether by analysis or by fracture, does so to control, or to try and control, the structural composition.

Examination under low powers, of the polished but unetched specimen, will only reveal the graphite and possibly the manganese sulphide constituent, both of which are revealed in Fig. 1. It will clearly show physical defects, however, such as a tendency to "sponginess," draws, dirt inclusions, etc. The graphite is free carbon. Carbon exists in cast iron in both the free and the combined condition. Up to approximately 0.8 per cent. combined carbon will be present structurally as pearlite, which consists of alternate plates of relatively pure iron known as ferrite, and plates of the compound iron carbide (Fe_3C), which has three atoms of iron to one of carbon. Fig. 2 illustrates the appearance of pearlite at high magnifications. Any excess of combined carbon over 0.8 per cent. will exist as free iron, which is known as cementite.

Apart from carbon, cast iron contains four other things which are present in quantity. These are silicon, phosphorus, sulphur, and manganese. Although these things are all that are generally taken into account, cast iron contains small amounts of many other elements. Probably the one occurring in the greatest quantity is titanium, which is often added at the blast furnace as a deoxidiser. Some brands of pig-iron also contain appreciable amounts of some of the following:—Arsenic, copper, nickel, tungsten, chromium, vanadium, aluminium, etc., to say nothing of dissolved gases such as hydrogen, nitrogen, oxygen (possibly also in combination as dissolved iron oxide), carbon monoxide, carbon dioxide, sulphur dioxide, etc.

How the Elements Exist.

The silicon enters into solid solution with the iron, and is therefore invisible. It is invisible in the same way that sugar dissolved in water is invisible. It is there, but cannot be seen. The phosphorus present exists as a phosphide eutectic.

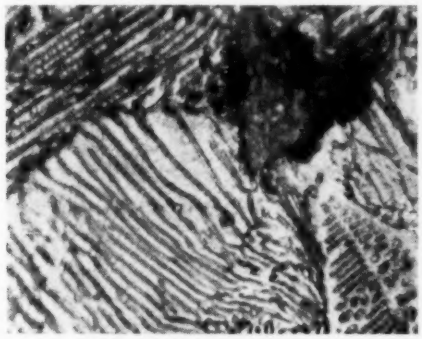


FIG. 2.—PEARLITE AT HIGH MAGNIFICATION.

It is easily recognised under the microscope. This phosphide eutectic is the last thing in the iron to solidify, and it is consequently squeezed about as solidification proceeds, thus giving rise to its characteristic formations. In normal iron, the whole of the sulphur present will be combined with manganese, and will be present in the form of small globules of manganese sulphide. The remainder of the manganese present combines with carbon to form manganese carbide, which acts in a similar way to iron carbide, and is indistinguishable from it. Thus graphitic carbon, combined carbon, silicon, phosphorus, sulphur and manganese are found in the structure as graphite, pearlite (composed of the iron and manganese carbides), phosphide eutectic, and manganese sulphide.

The foundryman is now in a position to recognise the different constituents under the microscope. Considering these elements singly and ascertaining what their influence is, and what happens during cupola melting, it will be supposed that an iron contains 1.9 silicon, 0.8 phosphorus, 0.10 sulphur, and 0.8 per cent. manganese, and is charged into the cupola. As is known, various changes occur.

EFFECT OF CUPOLA MELTING.

Carbon.

Iron has the power of dissolving carbon, which power increases as the temperature is raised. Case-hardening, for example, is an instance of carbon actually being absorbed by solid iron. The silicon has been referred to as being dissolved in iron as sugar dissolves in water. Carbon can be imagined to do very much the same thing in molten iron. Cold water dissolves a certain

* A Paper read before a meeting of the Newcastle Branch of the Institute of British Foundrymen, Mr. C. W. Freer presiding.
† See The Journal, April 5, 1923.

amount of sugar; if the water is heated, more sugar will dissolve. If the water is maintained at a constant high temperature and more sugar added, a point will be reached when no more will dissolve, this being known as the saturation point. If now the water is allowed to cool, sugar will be thrown out of solution, as the water, being at a lower temperature, has a lower saturation point. A parallel happening occurs in the case of iron and carbon—that is, molten iron constantly trying to saturate itself with carbon.

Iron going down through the cupola is heated, gradually increasing in temperature until it arrives at the top of the melting zone, where a very rapid increase of temperature takes place. As the outer layers of the piece of iron reach the melting point, they trickle away down through the hottest part of the melting zone, thereby becoming superheated. In this condition it is greedily trying to absorb more carbon, and, indeed, conditions are very favourable. There is iron at a high temperature, in small drops, every particle of which comes into intimate contact with carbon (coke) also at a very high temperature. The lower the carbon in the iron charged into the cupola, the greater the tendency to absorb carbon. The only thing lacking at this stage is time, and here, apart from composition, is practically the only chance to control the absorption of carbon. The more rapid the melting and the shallower the melting zone, the less time will the little drops

FIGS. 3 AND 3A.—GRAPHITE DISTRIBUTION IN THE SAME CASTING.

of superheated iron have to absorb carbon. The molten iron collects in the well of the cupola, still in contact with coke, but now on a falling temperature gradient. It is possible that more carbon is taken up whilst waiting to be tapped, but, on the contrary, it may be that some irons actually lose carbon at this stage.

Graphitic Carbon.

Suppose that the iron after its passage through the cupola contains 3.5 per cent. total carbon. This carbon, whilst the iron is molten, is all combined with iron, and is held in solution. The actual temperature at which an iron commences to solidify will vary according to its composition, but the main solidification will occur round about 1,130 deg. C. Just immediately after solidification, the iron carbide, which is not very stable in the solid form at high temperatures, starts to split up into its component parts. That is, $Fe_3C=3Fe+C$. This liberated carbon is the graphite. The iron is still semi-liquid when the first graphite forms, so that it is able to grow readily; therefore, the first or primary graphite is large. As the iron continues to cool, more graphite is thrown out. The amount of graphite thrown out will depend upon the total carbon held by the iron, the percentage of silicon, phosphorus, sulphur and manganese present, and especially upon the rate of cooling. This latter is largely a matter of section and size of casting; also initial casting temperature and temperature of mould. Cooling continues down to about 940 deg. C., when the phosphide eutectic solidifies, and the whole mass is then solid. Graphite still continues to be formed right down to about 700 deg. C., but naturally this graphite, forming in the now completely solid material, cannot grow so easily, and is consequently small in size. It is known as secondary graphite. If specimens from different castings and castings from different sources are examined it will be seen that the graphite can vary considerably in amount, size, shape, and distribution, each different variety having its influence on the physical properties of the iron in which it occurs. Fig. 3 illustrates this clearly.

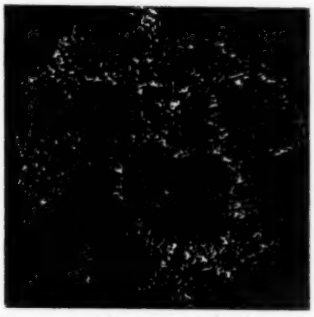


FIG. 4.—PHOSPHIDE EUTECTIC NETWORK STRUCTURE.

Suppose that in iron under consideration, which had 3.5 per cent. total carbon when it left the cupola, 3.0 per cent. of this has freed itself as graphite. This figure is 3.0 per cent. by weight, and does not represent the area or volume occupied in the iron. Grey cast iron has a specific gravity of about 7.15, and graphite about 2.2, so that every 1 per cent. of graphite by weight represents about 3.25 per cent. by volume; thus 3.0 per cent. graphite by weight actually represents 9.75 per cent. by volume. In other words, almost 10 per cent. of the bulk of the material forming a casting consists of small spaces or cracks filled with powdery graphitic carbon. The importance of keeping the graphite under control will be appreciated when it is regarded in this light. Although the graphite percentage may be identical in two irons, it does not follow that the volume occupied by the graphite will be the same in each case.

Combined Carbon.

The remainder of the carbon in the iron not liberated as free or graphitic carbon is converted into pearlite at about 700 deg. C. This pearlite consists of alternate plates of almost pure iron (ferrite) and the compound iron carbide (cementite), in the proportion of seven parts of ferrite to one of cementite.

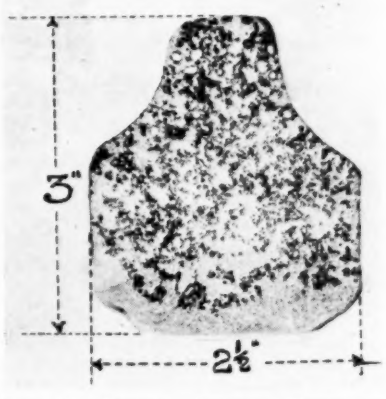


FIG. 5.—TYPICAL SULPHUR PRINT OF CAST IRON.

The atomic weight of iron is 55.84, and carbon 12. Therefore three atoms of iron and one of carbon would give a formula weight of 167.52 + 12 = 179.52. Therefore every 12 parts of combined carbon would equal 179.52 parts of cementite. In this case the combined carbon is 0.5 per cent., so that by simple proportion this gives 7.48 per cent. cementite. Pearlite consists of seven parts ferrite to one of cementite, so that

7.48 multiplied by 8 gives the amount of pearlite, which is 59.84 per cent. A simpler way of arriving at this figure (providing the amount of combined carbon is less than 0.8 per cent.) is to multiply the percentage of combined carbon by 120. Thus 0.5 multiplied by 120 equals approximately 60 per cent. pearlite, which is near enough for practical purposes.

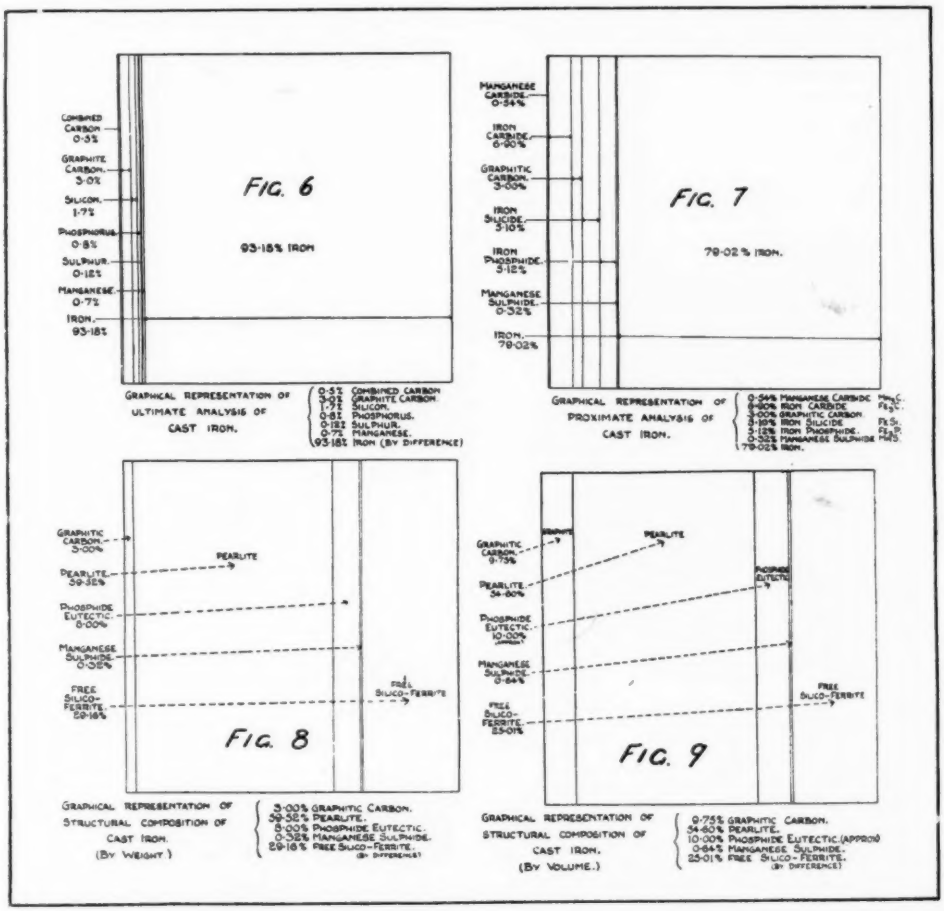
Silicon.

A certain amount of silicon is oxidised and passes into the slag during melting. Commencing with an iron containing 1.9 per cent., probably 0.2 per cent. would be lost in the cupola, the iron finishing with 1.7 per cent. The loss of silicon depends upon the conditions prevailing in the cupola, hard driving and much excess air increasing this loss. The silicon forms a silicide of iron, and this is held in solution by the remainder of the iron. Assuming that it is FeSi that is formed, then 1.7 per cent. silicon will form 5.1 per cent. iron silicide.

The effect of silicon is to reduce slightly the solubility of carbon in iron, and to promote graphitisation. That is, increasing the silicon tends to lower the total carbon, but increases the amount thrown out as graphite. The very considerable effect of silicon in this latter respect is very well known. Everyone would know what to expect in two similar irons, one of which contained 1.0 per cent. silicon and the other 2.0 per cent., for instance. Both the effects mentioned can be obscured or prevented by the influence of other things.

Phosphorus.

Phosphorus has also the effect of lowering the carbon saturation point of iron, and although it is apparently without direct effect on the condition of the carbon, it has the indirect effect of lengthening the solidification range, and thereby allowing the formation of large, coarse graphite. The amount of phosphorus going into the cupola remains unchanged during melting, and the finished iron will contain practically the whole of the phosphorus charged. Phosphorus has a very considerable effect on the fluidity of the iron. The reason for this is that it combines with iron 1.0 per cent. of phosphorus, forming 6.4 per cent. iron phosphide (Fe_3P). This iron phosphide in turn forms a eutectic with more iron, and it is this phosphide eutectic, with its melting point of about 980 deg. C., which gives fluidity. In an actual cast iron the phosphide is not solid until about 940 deg. C. The eutectic of grey cast iron consists, according to the late Dr. Stead, of approximately 90 per cent. iron and 10 per cent. phosphorus. The particular iron under consideration would therefore contain 8 per cent. phosphide eutectic. It should be noted that in strong irons the phosphide is generally found to be arranged in a network formation as shown in Fig. 4.



Sulphur.

During the descent through the cupola, and especially on standing in the well awaiting tapping, cast iron picks up sulphur from the coke. The amount picked up is variable, depending upon the conditions of melting and upon the sulphur content of the coke. Probably an average gain would be about 0.02 per cent. In the iron under consideration the final sulphur content might be 0.12 per cent. Sulphur exists in cast iron as manganese sulphide, every 0.10 per cent. sulphur forming 0.27 per cent. manganese sulphide. Thus 0.12 per cent. sulphur would be equivalent to 0.324 per cent. manganese sulphide. Sulphur alone, in the absence of manganese, has a very pronounced effect on the carbon, but when at least twice as much manganese is present, manganese sulphide is formed, and the influence then is only apparently the local influence of the hard crystals of manganese sulphide. These hard crystals are believed to be good from a wearing point of view.

Sulphur has rather a bad name in the foundry—

XUM

unjustifiably so in the author's opinion (that is, when kept under control)—and it is the scapegoat for many troubles for which no other reason can be assigned.

A very practical method of judging the approximate amount of sulphur present is to take a sulphur print. The piece of iron to be tested is machined or filed flat, and then polished with emery—the finer the finish the better the result. Photographic bromide paper is then soaked in dilute sulphuric acid and pressed into intimate contact with the surface, and wherever a globule of manganese sulphide exists, it will leave a corresponding brown mark on the photographic paper. If the conditions are standardised and adhered to, an idea of the amount of sulphur present and its distribution can readily be seen. A typical sulphur print is shown in Fig. 5.

Manganese.

Manganese is generally not present in cast iron in greater quantity than 1.5 per cent., and is usually below 1.0 per cent. Manganese has a great affinity for carbon, and high-manganese irons tend to pick up carbon in the cupola. Manganese is slightly oxidised during melting, ordinarily about 0.1 per cent. being lost.

The effect of manganese is directly opposite to that of silicon, which lowers the carbon saturation point and promotes graphitisation. Manganese increases carbon absorption and opposes graphite formation. The reason for this is thought to be that having formed manganese sulphide with all

FIG. 10.—CAST IRON FREE FROM FERRITE.

the sulphur present, the remainder of the manganese unites with carbon, forming manganese carbide, which is much more stable than iron carbide at high temperatures. Manganese is therefore regarded as a hardener, but where insufficient manganese is present in a high-sulphur iron, the addition of more manganese will then have the effect of softening the iron. The iron under consideration would probably finish with 0.7 per cent. manganese; 0.2 per cent. of this would form manganese sulphide with the sulphur present, and the remaining 0.5 per cent. would combine with carbon, forming 0.54 per cent. manganese carbide.

Ultimate, Proximate, and Structural Composition.

It will thus be seen that chemical analysis alone gives only the ultimate amounts of the elements present in the iron. It does not indicate how these elements are united with the iron, nor what part they play in the actual structure, which is really the most important point of all. Knowing the chemical analysis, however, it is possible by calculation to build up the proximate composition, and thereby obtain an idea of the compounds present in the iron. These are shown in Table I.

The proximate composition, however, still does not go sufficiently far, and it is desirable to ascertain what the structural composition is. The manganese carbide and iron carbide together form the cementite, which, with seven parts of ferrite, forms the pearlite, which is seen under the microscope. The iron silicide is dissolved throughout the whole of the ferrite, and consequently cannot be seen. The phosphide forms a eutectic with more iron. The sulphur exists as manganese sulphide distributed throughout the mass in little globules; so that the actual structural composition by weight is as shown in Table I. The different constituents have different specific gravities, so that it is necessary to correct these figures to realise the amounts as actually seen under the microscope. The corrected figures showing the composition of the iron by volume are also shown in Table I.

The whole of these facts are summarised graphically in Figs. 6, 7, 8, and 9. It will be seen that in place of the 7.0 per cent. or so of elements which this iron contains, 75 per cent. of the mass is occupied by constituents formed from the carbon, phosphorus, sulphur and manganese. Of the 75 per cent., 54.6 per cent. is due to the combined carbon in the form of pearlite.

Carbon is practically the most important thing in cast iron. The other elements are important indirectly, inasmuch as they affect the amount and condition of the carbon in the final product.

Effect of Changes of Composition.

It will be obvious now that slight changes of ultimate composition will produce drastic changes in structural composition. The retention of a little over 0.2 per cent. more carbon in the combined state, for instance, would be sufficient to take up the whole of the free ferrite, and the matrix would then be completely pearlitic, as is shown in Fig. 10. Very slow cooling might cause practically the whole of the carbon to be freed as graphite, in which case the matrix would then consist of nearly all free ferrite, and, in addition, the material would be further weakened by the presence of a large amount of free graphite.

TABLE I.—*Showing how the Constituents in Cast Iron can be Considered as Existing.*

ULTIMATE ANALYSIS.	PROXIMATE COMPOSITION.
%	%
0.50 Combined carbon.	0.54 Manganese carbide.
3.00 Graphitic carbon.	6.90 Iron carbide.
1.70 Silicon.	3.00 Graphitic carbon.
0.80 Phosphorus.	5.10 Iron silicide.
0.12 Sulphur.	5.12 Iron phosphide.
0.70 Manganese.	0.32 Manganese sulphide.
93.18 Iron (by difference).	79.02 Iron (by difference).
STRUCTURAL COMPOSITION. (BY WEIGHT.)	**STRUCTURAL COMPOSITION. (BY VOLUME.)**
%	%
59.52 Pearlite.	54.60 Pearlite.
3.00 Graphite.	9.75 Graphite.
8.00 Phosphide eutectic.	10.00 Phosphide eutectic (approx.).
0.32 Manganese sulphide.	0.64 Manganese sulphide.
29.16 Free silico ferrite.	25.01 Free silico ferrite.

These figures are obtained by assuming the undermentioned specific gravities.

SPECIFIC GRAVITIES.

Specific gravity of final iron	7.15
,, ,, graphite	2.20
,, ,, pearlite	7.8
,, ,, manganese sulphide ...	3.55
,, ,, phosphide eutectic—assumed to be a little less than cast iron.	

Increasing the silicon content would have a similar effect; in fact, any slight change in ultimate composition produces a corresponding, but very much greater, change in structural composition.

Structure and Physical Properties.

The physical properties of cast iron depend entirely on the structural composition and arrangement, so that any change in structural composition is followed by a change of physical properties. As set forth previously, structural composition depends upon chemical composition, but, in addition, it is also influenced by thermal conditions, so that it is possible to have a difference of structural composition, and therefore of physical properties, in two similar castings poured from the same ladle, but possibly at different temperatures and cooled at different rates. It is even possible to have differences of structural composition in a single casting, of which a cast-iron propeller is the classical example. In one such propeller which the author has examined the total carbon was practically the same at the tip and boss, namely, 3.76 per cent. The tip, however,

XUM

had 0.62 per cent. of this in the combined form, but at the boss practically the whole amount existed as free graphite.

Cast iron may be considered as a very impure steel of a carbon content equal to the combined carbon content of the iron, but that the continuity of the matrix is broken up in all directions by little cracks filled with powdery graphite. The strength of the iron, therefore, is primarily dependent upon the amount of graphite present, and secondly, on the strength of the matrix, which in turn is dependent principally upon the amount of combined carbon present.

Consideration of the Graphite.

Assuming equal amounts of graphite in two irons, the one which has it in the finest possible form will be stronger than one where the graphite occurs in large flakes. This fact is self-evident and needs no elaboration. (See Fig. 3.)

Another factor is the arrangement of the graphite flakes. Some irons have the graphite arranged in very definite "groups," and here again it is evident that this formation, irrespective of size of flake, will make for strength. This arrangement is associated with the phosphide "network" previously mentioned.

Coarse graphite, apart from being a source of weakness, is the cause of "porosity" or "weeping" of castings on water test. The graphite flakes act as channels along which liquid or gas can penetrate.

The liability of such castings as internal combustion engine cylinders and liners, etc., to

FIG. 11.—ILLUSTRATES THE PENETRATION OF CORROSION BY MEANS OF THE GRAPHITE FLAKES.

"grow," is to a great extent determined by the graphite for this reason. Fig. 11 illustrates a piece of cast iron which has been in contact with corrosive mine water. The action of the graphite in providing channels along which the corrosive fluid, or oxidising gas can travel, and eventually disintegrate the whole material, is clearly shown.

A point touched upon earlier was that two irons with identical amounts of graphite by weight might have different amounts of graphite by volume. As the volume is the major concern, this would be equivalent to the iron containing more graphite, and being, in consequence, weaker. It is not possible at the moment to produce any direct proof of this, although the author has tried in many ways to find a method for the accurate determination of the amount of graphite present by volume. From observation, practically all irons appear to have more graphite by volume than the amount calculated from the specific gravities of graphite and cast iron. For instance, assuming 3.0 per cent. of graphite by weight represents approximately 10 per cent. by volume, then what may be termed "synthetic graphite structures" have been prepared, representing exactly 10 per cent. It will be obvious from a comparison of Figs. 12 and 13 (which both contain 10 per cent.) that the apparent amount present depends to some extent upon the state of division—the finer the state of division, the larger the apparent amount. However, taking the more finely divided specimen and comparing it with an actual cast iron containing 3.0 per cent. graphite by weight (Fig. 14), it will be seen that the iron appears to have much more than 10 per cent. by volume.

This is partly accounted for by the fact that it is impossible to prevent the edges of the graphite flakes being slightly worn away and rounded off during the polishing; so that the graphite of any iron must appear under the microscope to be a little worse than it really is. Even so, the apparent increase of graphite due to polishing should be comparable in all specimens, and would not account for two irons of similar percentages of graphite by weight showing apparently different amounts by volume. It is certainly a point which requires further investigation, as it is of very practical importance, having some bearing on so-called "inherent qualities."

Considering again the combined carbon, it can be fairly safely accepted that other things being equal, an increase of combined carbon up to approximately 0.8 per cent. (with corresponding decrease in graphite) will give a stronger matrix; hence the great amount of publicity during the last year or so, concerning "Pearlitic Cast Iron." Pearlitic cast iron is simply iron where the whole of the matrix or ground mass consists of pearlite. Pearlitic cast iron is no one's secret or patent, although the methods to ensure its automatic production may be. The phosphide eutectic is hard

FIG. 12.—GRAPHITE STRUCTURE OCCUPYING 10 PER CENT. OF THE VOLUME.

and brittle, so that both the tensile and transverse strength will decrease as the amount of phosphide increases.

It follows from the foregoing that the strongest irons are those which contain a minimum amount of graphite in the most finely divided form and preferably "grouped"; and having in addition, a completely pearlitic matrix with only a small amount of phosphide eutectic present.

Composition and "Inherent Qualities."

Cast iron is a very complex material, and its study has been almost neglected until quite recent years, so that even now there is much to learn concerning it. Despite this, however, cast iron is governed by ordinary laws, and possesses no supernatural qualities. It has been the custom in the past for some foundries to rely on certain stereotyped mixtures or brands of iron. These possibly were found by experience to suit the particular class of casting made. Either because of excessive credulance, or very probably through fear of the consequences, any change from the mixture was to be avoided. In this connection, blind belief in the superior qualities of certain irons has undoubtedly been deliberately fostered by iron producers and agents for purely commercial purposes. Possibly in the case of the stereotyped mixture, where efforts were made to try and improve or cheapen it, and the experiments failed, these failures would be put down to inferior qualities of the new irons used; whilst

XUM

in reality it would be nothing more or less than unsuitable chemical composition. This is possibly one of the ways in which the "inherent quality" theory originated.

Another and more modern school adhere to the belief that certain irons have inherent qualities which influence the graphite, so that a large coarsely graphitic iron, even on remelting, will cause the resulting mixture also to have coarse graphite, even going so far as to say that large coarse graphite persists through the cupola.

The whole crux of the situation can be summed up in the following:—If a foundryman takes any mixture of irons, melts and casts it, then any other mixture of irons melted and cast under identical conditions, and with exactly the same composition, will have identical physical properties. The difficulties in the way of doing this, however, are enormous; in fact, it is almost impossible in the scientific sense. It is difficult enough to analyse and control the four elements, silicon, phosphorus, sulphur and manganese; but when in addition the control of the amount of total carbon and its formation into certain amounts of graphite and combined carbon is sought, then the difficulties increase greatly. Assuming that it was possible accurately to control the melting, pouring temperature, and rate of cooling, and that one finished with two irons of identical amounts of combined carbon, graphitic carbon, silicon, phosphorus, sulphur and manganese, then these two irons would have exactly similar physical properties. If they were not absolutely identical, then one would have to look further. There is no accurate method of estimating dissolved iron-oxide in cast iron, nor, indeed, is it absolutely certain that iron-oxide can actually be present in cast iron. It is not known whether or not nitrogen is absorbed during manufacture and subsequent melting; or if so, in what form it exists, and what its influence is. Then what is the effect of occluded gases such as hydrogen, carbon monoxide, carbon dioxide, sulphur dioxide, etc.? Again, the estimation of small amounts of arsenic, copper, nickel, chromium, tungsten, titanium, vanadium, etc., is very tedious and difficult, yet these things must have an influence. It will be appreciated how difficult a thing it is to produce two irons, in the scientific sense, exactly alike. Yet people constantly assert, and apparently believe, that by running the same mixture through the cupola months on end, iron of identical and consistent quality will be produced.

Fig. 13.—Graphite occupying 10 per cent. of the Volume (compare Fig. 12).

Practical Considerations.

If every foundry were able to control the exact composition of the iron in use, foundrymen would very quickly have an end of the "inherent quality" theory. Like sulphur, it is a good excuse for something which is not understood. The more perfect the control, the more consistent in every respect will the final product be.

Having entered into the theoretical side of the structural composition of cast iron a few of the practical considerations for the production of high-quality iron will be considered in conclusion.

Remembering the statement made earlier, that strong iron will have a minimum amount of graphite in a finely divided state in a pearlitic matrix, and containing only a small amount of phosphide—how is this to be achieved? Obviously the first step towards a low graphitic carbon is a low total carbon. This simple, fundamental fact is practically the whole secret of strong iron, yet its production in the cupola is one of the most difficult problems to be solved. It is almost useless buying high-priced, low total-carbon pig-irons, and by melting in an ordinary way, expect to get low total-carbon castings. The extent to which low total-carbon iron picks up carbon in the cupola can be gauged from the fact that if charges of steel and ferro-silicon alone are put through, the resulting iron will show almost 3 per cent. total carbon. It is seldom possible in ordinary working, to get below about 3.2 per cent. total carbon in the cupola. The problem is one which the author has not yet solved to his own satisfaction, and it is hoped to have the experiences and opinions of others on this very important point.

The silicon content should be regulated according to the section of the casting. The following figures can be taken as a very rough guide:—

¼-in.	section	...	2 per cent. silicon.
1 in.	,,	...	1.7 per cent. silicon.
1½ in.	,,	...	1.5 per cent. silicon.
2 in.	,,	...	1.3 per cent. silicon.

The amount of phosphorus permissible will depend upon a compromise between strength and fluidity. For strong iron, at the most, no more than 0.5 per cent. phosphorus should be present, and no more than 1 per cent. should be present in any casting.

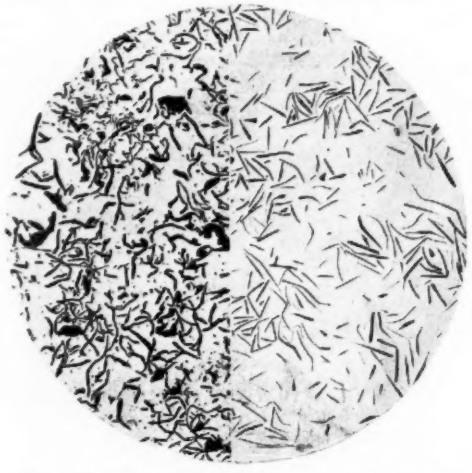


Fig. 14.—The Left Micro apparently contains much more than 10 per cent. Graphite.

The actual amount of sulphur is not very important, and if round about 0.10 to 0.12 per cent. will be satisfactory, providing about 0.7 to 0.8 per cent. manganese is present.

Hot, rapid melting is considered to be essential, as also is a high casting temperature. Careful skimming of the ladle before casting is a point which should not be neglected. Dusting the clean surface of the molten iron with fine parting sand after skimming, is a little refinement which has been found to be worth the trouble. The effect of this is to form a crust which effectually holds the small globules of slag and manganese sulphide which continually keep rising to the top. The use of pouring basins with accurately fitting plugs is a further refinement which pays.

Control of composition is not easy. It is only possible by means of much systematic routine analysis; but it will have to come, for the advance of the Diesel engine, and the tendency to cut down section and weight, will make it imperative if the foundries of this country are to hold their own. It is not claimed that by its adoption troubles will instantaneously vanish for ever, and that 20-ton testbars will be the order of the day; but its use will certainly shed a light where previously darkness held sway.

A New Aluminium Alloy—Alpax.*

By Leon Guillet, Paris, France.

Translated by ROBERT J. ANDERSON, Boston, Mass.

(*Abstract.*)

INTRODUCTION.

At a recent motor-car and aircraft exhibition in France there was shown at the booths of two important metallurgical concerns a new aluminium alloy, known as "alpax," which should be of interest to manufacturers desirous of using an alloy of low density and moderately high strength. The problem of producing wrought aluminium alloys having this combination of properties is now fairly well solved, and progress is being made continually in the production of rolled and drawn manufactures which are light and strong. Thus, there are now available to manufacturers the duralumin-type alloys, which have excellent properties. Thus, ordinary wrought duralumin has density of 2.7 to 2.8 and tensile strength of 22.8 to 25.4 tons per sq. in. (36 to 40 kg. per sq. mm.), and, on the basis of recent British investigations, it is expected that commercial manufactures in duralumin will soon be available, having strength of 31.7 to 35.1 tons (50 to 55 kg.). While the problem of producing wrought high-strength light aluminium alloys has been fairly well solved, the question of cast high-strength alloys has not been. In the cast condition, ordinary duralumin does not yield the desired mechanical properties, while the heat treatment necessary for enhancing its strength generally gives an alloy heterogeneous as to internal structure. The mechanical properties of cast duralumin are much inferior to those of the wrought alloy.

As is known, the usual light aluminium-casting alloys are only moderately strong. The most common aluminium-casting alloys are (1) binary aluminium-copper alloys, containing up to 15 per cent. copper; (2) binary aluminium-zinc alloys, containing up to 30 per cent. zinc; and (3) ternary aluminium-copper-zinc alloys, *e.g.*, those with 2 to 3 per cent. copper, 15 to 18 per cent. zinc, and remainder aluminium. The range of tensile properties for these classes of alloys is: Tensile strength, 7.6 to 9.5 tons per sq. in. (12 to 15 kg. per sq. mm.), and elongation, 3 to nil per cent. It may be pointed out in passing that certain of the binary aluminium-copper alloys retain their strength fairly well at moderately elevated temperatures, while the zinc-bearing alloys weaken rapidly at increasing temperatures. Of other light aluminium alloys, the binary aluminium-magnesium and aluminium-manganese alloys do not yield especially good results in the cast condition, and, taken by and large, the ordinary commercial light aluminium-casting alloys yield maximum tensile strength of only about 9.5 tons per sq. in. (15 kg. per sq. mm.) and elongation of 0 to 3 per cent. Most of the moderately strong alloys are quite brittle. Substantially pure aluminium (*i.e.*, 99.5 per cent. Al), when cast, has tensile strength of 4.4 to 6.2 tons per sq. in. (7 to 10 kg. per sq. mm.) and elongation of 8 to 12 per cent.

Preparation of Alpax.

The alloy known by the trade name alpax is an aluminium silicon alloy containing 13.5 per cent. silicon and prepared according to certain methods. The mechanical properties of alpax are much better than those of the usual light aluminium-casting alloys. It should be stated at the outset that if this aluminium-silicon alloy is prepared simply by dissolving silicon in aluminium, the mechanical properties are relatively poor, and the resulting alloy is not satisfactory. In order to secure the high mechanical properties which the alloy is capable of attaining, it is necessary to employ a so-called modifying process. The method of refining, as applied to alpax, has been described and patented by Pacz. This process is described briefly below.

The aluminium is first melted and raised to a high temperature, say 1,000 deg. C. (Heating to such a high temperature is normally regarded as inadvisable in ordinary foundry melting for the preparation of aluminium alloys.) When the aluminium is at a temperature of, say, 930 deg. C., the requisite amount of silicon is added, and then an addition of alkaline salts, preferably alkaline fluorides, is made. The melt is then stirred and allowed to stand. After a short time a dross, consisting of the melted salts which were added plus alumina, silica, and sodium oxide, forms and rises to the surface. The melt is next skimmed thoroughly to remove all dross, and the alloy is cast at the ordinary temperature, *i.e.*, 710 to 750 deg. C.

This method of preparation confers upon the 86.5:13.5 aluminium-silicon alloy, *i.e.*, alpax, the properties which it is capable of attaining.

Properties.—In order to make definite comparison between the properties of modified and normal aluminium-silicon alloys, the writer first made a series of tests to determine the properties of the ordinary alloys with increasing percentages of silicon. Assuming that the forms of the equilibrium diagram for the refined and unrefined alloys are the same, the following conclusions can be drawn off-hand, viz., (1) the aluminium-rich solid solution (0 to 1.5 per cent. silicon) will have substantially the same properties as aluminium, with, doubtless, some change in the tensile strength and elongation; (2) alloys consisting of the solid solution and eutectic (*i.e.*, 1.5 to 10.5 per cent. silicon) will have their elastic limit and tensile strength increased with increasing silicon, at least, if they are homogeneous and not contaminated by oxides in these alloys; the elongation and impact resistance should decrease with increasing silicon; and (3) the hyper-eutectic alloys (*i.e.*, those containing more than 10.5 per cent. silicon) should have poorer mechanical properties with increasing silicon.

Some tests were made on unrefined aluminium-silicon alloys drawn at 425 to 450 deg. C. These alloys were prepared simply by adding solid silicon to liquid aluminium. The aluminium used contained 99 + per cent. Al, while the silicon contained 94.4 per cent. Si, 2.3 Al, 2.1 Fe, and 1.1 per cent. Ca. (0.1 per cent. not determined). Analysis was made of the resultant alloys for iron and silicon. The series of alloys varied in composition in the range 1.19 to 16.40 per cent.

TABLE I.—*Mechanical Properties of Hot-Rolled Aluminium-Silicon Alloys, Unrefined.*

Composition of alloy, elements per cent.			Elastic limit, tons per sq. in.	Tensile strength, tons per sq. in.	Elongation, per cent.	Reduction in area, per cent.	Brinell hardness.	Charpy impact resistance, kg.-m. per sq. cm.	Angle.°
Al.*	Si.	Fe.							
98.12	1.19	0.69	3.2	6.9	30	68.1	36	9.4	bent
97.64	1.70	0.66	2.9	7.1	30	68.1	37	9.4	bent
95.74	3.40	0.86	4.4	8.5	21	47.6	44	6.2	155
93.98	5.15	0.87	4.4	8.5	22	48.6	44	5.0	144
92.69	7.31	—	4.9	7.2	22.5	49.7	31	3.2	171
90.25	9.75	—	5.4	11	17.5	45.5	38	2.6	172
86.85	13.15	—	5.1	9.7	18	37.7	46	1.3	172
83.60	16.40	—	4.5	10.4	18	28.3	48	2.4	173

* Aluminium by difference.

* Extracted from a Paper read before the American Foundrymen's Association.

silicon, remainder aluminium (cf. Table I). Mechanical tests were made on these alloys under the following conditions:—(1) Tensile test, on round bars, 13.8 mm. diameter and 100 mm. gauge length; (2) Brinell hardness, 1,000 kg. load, 10 mm. ball; and (3) notched bar impact test, Charpy machine, on 10 by 10 by 55-mm. bars, rounded notch 2 by 2 mm.

The results of these tests are given in Table I.

It should be pointed out that the last alloy (*i.e.*, the one containing 16.40 per cent. silicon) was very heterogeneous, and in the cast ingot from which drawn the silicon content of the upper part was considerably higher than that of the lower. Thus, in the original ingot, which was 100 mm. diameter and 400 mm. high, the silicon content of the top was 18.61 per cent. and that of the bottom was 14.26 per cent.; the composition aimed at was 15 per cent. silicon. It might be concluded from this that in the case of hyper-eutectic alloys the silicon (density 2.4, as against 2.7 for aluminium) rises on solidification, thus causing non-homogeneity. This might, of course, be expected, since in the hyper-eutectic alloys the silicon is the pro-eutectic constituent, and during the course of freezing silicon would precipitate out first and continue precipitating out on cooling as the mother metal became more concentrated towards the eutectic composition.

Tests were next made on the mechanical properties of cast unrefined alloys. The test pieces were cast attached to the ingots for drawing (*i.e.*, the ingots drawn in the tests described above). Hence, the worked and cast alloys had substantially the same compositions.* Table II. gives a summary of the results obtained on the cast alloys.

As has been pointed out, the maximum solid solubility of silicon in aluminium is 1.5 per cent., and the existence of this solid solution indicates that quenching may have some influence in affecting the amount of free silicon present in the alloys.† Some tests were made to determine the effect of quenching on the properties of a series of alloys. Samples of hypo-eutectic alloys were quenched from 475 deg. C. in water at 20 deg. C. Table III gives comparative figures for the mechanical properties of the alloys in the annealed and quenched conditions. These mechanical tests were made after the samples had stood for 48 hours at the ordinary temperature after the heat treatment. Referring to the data of Table III, it will be seen that the effects of quenching are, in general, slight. The tensile strength is increased slightly, while the elongation and reduction in area vary irregularly. The impact resistance is increased somewhat by quenching, but the elastic limit is decreased rather markedly.

As would be expected the density of the aluminium-silicon alloys decreases slightly with increasing silicon content. Table IV gives some figures for the theoretical density and the density as found for three alloys. The theoretical density was calculated, using 2.7 for the density of aluminium and 2.4 for that of silicon. It should be stated that the aluminium employed in making up these alloys was relatively impure.

On the basis of tests made by the writer and those of other investigators, it may be concluded that the maximum tensile properties of unrefined aluminium-silicon alloys cannot exceed,—

For Worked Alloys.—Tensile strength, 10.6 to 10.8 tons per sq. in. (16-17 kgs. per sq. mm.); elongation, 17-18 per cent.; and Charpy impact resistance, 2 to 3 kg.-m. per sq. cm.

For Cast Alloys.—Tensile strength, 9.3 to 10.2 tons per sq. in. (15-16 kgs. per sq. mm.); elongation, 2-3 per cent.; and Charpy impact resistance, 0.5 to 1.0 kg.-m. per sq. cm.

TABLE II.—*Mechanical Properties of Cast Aluminium-Silicon Alloys, Unrefined.*

Composition of alloy, elements per cent. Al.*	Si.	Yield, tons per sq. in.	Tensile strength, per sq. in.	Elongation, per cent.	Reduction in area, per cent.	Brinell hardness.	Charpy impact resistance, kg.-m. per sq. cm.
98.80	1.20	7.9	9.9	2.0	5.9	50.5	0.6
98.30	1.70	8.7	10.5	2.5	8.7	60.5	0.5
96.60	3.40	10.1	10.1	2.0	7.3	61.0	0.3
94.87	5.13	9.8	10.0	3.5	5.9	59.0	0.2
92.70	7.30	(?)	5.9	2.0	(?)	34.0	2.0
90.05	9.95	(?)	7.9	3.0	(?)	44.5	2.5
87.85	12.15	(?)	9.7	1.2	(?)	62.0	1.6

* Aluminium by difference.

TABLE III.—*Mechanical Properties of Worked Aluminium-Silicon Alloys, Unrefined, Annealed and Quenched.*

Composition of alloy elements per cent.		Condition of alloy.	Elastic limit, tons per sq. in.	Tensile strength, tons per sq. in.	Elongation, per cent.	Reduction in area, per cent.	Brinell hardness.	Charpy impact resistance, kg.-m. per sq. cm.	Charpy impact resistance, Angle.°
Al.*	Si.								
98.81	1.19	Annealed	3.2	6.9	30	68.1	36	9.4	bent
98.81	1.19	Quenched	2.2	7.4	27	64.4	40	9.9	bent
98.30	1.70	Annealed	2.9	7.1	30	68.1	37	9.4	bent
98.30	1.70	Quenched	2.2	7.7	29	64.7	40	11.8	bent
96.60	3.40	Annealed	4.4	8.5	21	47.6	44	6.2	155
96.60	3.40	Quenched	2.5	8.8	24	53.7	58	7.5	128
94.85	5.15	Annealed	4.4	8.5	22	48.6	44	5.0	144
94.85	5.15	Quenched	3.3	9.2	24	49.7	51	6.9	140

* Aluminium by difference.

The Aluminium Alloy Alpax.

Definition has been given previously as to what is understood by the aluminium alloy alpax. The alloy is characterised not only by its silicon content but also by the modifying process which is necessary in order to confer upon it the desired properties. Modifying can also be applied to alloys containing percentages of silicon different from that in alpax (*i.e.*, 13.5 per cent. silicon), and it is apparently desirable for all hypo-eutectic alloys.

It is of interest to discuss the effect of the refining process on the structure of the alloys. If the aluminium-silicon eutectic alloy, prepared without refining, be examined, it will be found to be heterogeneous, as has been pointed out. Large isolated grains of silicon exist in such an alloy, and there is a strong tendency toward segregation when cast into ingots, *i.e.*, the silicon content of the top of a cast ingot is higher than that in the bottom. It has been shown experimentally that large grains of free silicon and segregation in cast ingots are not found in the alloy when refined.

Macroscopic examination is useful in showing the difference between refined and unrefined aluminium-silicon alloys. Refining has a marked

* Translator's note: It is not stated whether the alloys were chill cast or sand cast, but presumably they were chill cast. There will be noted some variations in the silicon content of the drawn and cast alloys (cf. Tables I and II).

† Translator's note: Since the solid solubility of silicon is apparently but little, if any, affected by temperature, quenching could have but little, if any, effect on the amount of free silicon present in originally stable and homogeneous alloys, and consequently on the properties.

effect upon the character of the pipe formed in cast ingots. Thus, in refined alloys, the depth of pipe in circular ingots, *e.g.*, 100 mm. dia. and 400 mm. high, is less and the piped volume is more scattered than in unrefined alloys.* In unrefined alloys the pipe pocket is surrounded with large crystals of silicon, while in refined alloys the structure is more homogeneous (see Figs. 1-4).

Refining has noticeable effect upon the hardness of aluminium-silicon alloys, particularly upon the uniformity of hardness in given examples. Thus, if Brinell-ball impressions are made at a number of successive points across the surfaces of polished samples, it is found that the hardness values are much more regular for modified than for normal alloys. Thus, the following ranges of hardness values have been found for 86.5 : 13.5 aluminium-silicon alloy; viz., for normal alloy, Brinell hardness number = 46 to 53; and for modified alloy, Brinell hardness number = 53 to 57.

While macrographic examination is useful in showing the difference in structure between the modified and normal alloys, this is really not necessary, since simple fracture of rather large ingots (because the rate of cooling evidently has considerable influence upon segregation) readily shows the difference. On fracture, large crystals of silicon are found in the centre of unrefined ingots, while the grain is fine and regular in the case of refined ingots.

Microstructure. — Microscopic examination readily shows the difference between refined and unrefined aluminium-silicon alloys. Examination of alloys with increasing percentage of silicon up to the eutectic composition (and exceeding 1.5 per cent. silicon) shows increasing amounts of eutectic, as would be expected from the diagram of thermal equilibrium. In the hypo-eutectic alloys of composition between 1.5 and 10.5 per cent. silicon, the structure consists of the eutectic plus the aluminium-rich aluminium-silicon solid solution.

The segregation which occurs in cast ingots with respect to the silicon content at the top and bottom is shown by micrographs.

Nature of the Refining Process.

As has been pointed out, aluminium-silicon alloys prepared by direct electrolysis of a suitable mixture of salts have structures similar to those of the alloys which have been refined by Pacz's process; moreover, similar structures are obtained when the alloys are made by the method of Wöhler, *i.e.*, reduction of potassium-silicon fluoride by aluminium. It is of especial interest to state that the refined alloys lose their characteristic structure on remelting, and the refining process should be applied on remelting scrap in foundry practice.

While the writer was quite sceptical at first regarding the alleged effects of the refining process, the desirable effects of the processes can now be affirmed. The question naturally arises: What is the correct explanation of the refining action? One conclusion seems certain; viz., the addition of the alkaline salts has the effect of dissolving the alumina and silica, which can exist in the unrefined alloys, causing them to pass into the dross. Moreover, it appears that when the salts are added the silicon is wetted more easily* by the aluminium and consequently is dissolved more easily. Jeffries and Curran attribute the principal rôle in the refining action to the alkaline fluoride. A small amount of sodium is set free, silicon fluoride is formed, and the sodium dissolves in the aluminium. Curran has obtained the normal structure of the refined alloys by adding a small amount of sodium to liquid aluminium-silicon alloys, and he concludes that a ternary aluminium-silicon-sodium alloy is formed, whose normal structure is similar to that of refined alloys. He recognises, however, that the addition of sodium may not be detected in the final alloy, but the influence of its presence is found in the altered microstructure.

It seems logical to the writer to believe that the

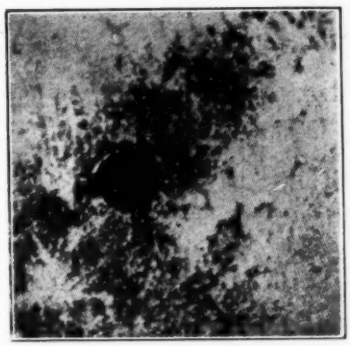


FIG. 1.—MICROGRAPH OF ALUMINIUM SILICON ALLOY (86.5 : 13.5), UNREFINED, SHOWING PIPE.

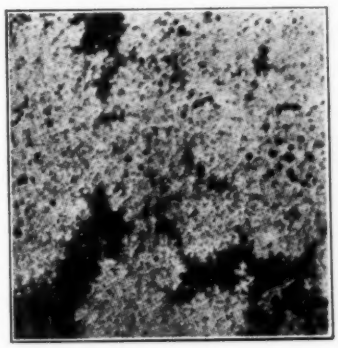


FIG. 2.—AS FIG. 1, BUT SHOWING GROSS STRUCTURE × 6 DIAS.

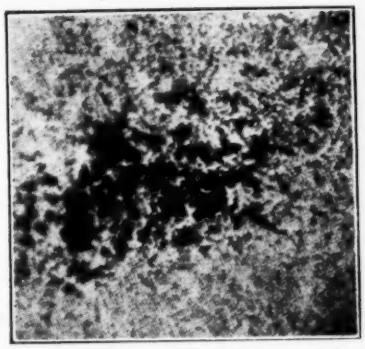


FIG. 3.—MICROGRAPH OF ALPAX ALLOY (13.5 PER CENT. Si), SHOWING PIPE. IT HAS BEEN REFINED.

FIG. 4.—SAME AS FIG. 3, SHOWING GROSS STRUCTURE × 6 DIAS.

* Translator's note: While tests have not been made as to the comparative contraction of refined and unrefined aluminium-silicon alloys, apparently there may be some difference in the values, since refining affects the character of pipe (cf. paper by the translator on the contraction of aluminium alloys.—A.F.A. Proceedings, Vol. 31.).

* Translator's note: This is equivalent to saying that addition of alkaline salts changes the surface tension of the liquid aluminium.

effect of adding a strong reducing agent like sodium is to reduce the oxides (alumina and silica) present in the bath. For the present, the precise action in refining cannot now be explained, despite recent investigations, *e.g.*, that of Edwards, who indicates that the addition of modifying agents, characterising the production of refined alloys, very markedly affects the composition and melting point of the eutectic. It might very well be asked whether refining has not simply the effect of preventing segregation. If so, then it would be deduced that the ordinary unrefined alloy is not normal (*i.e.*, is really the modification), while the refined alloy is the normal one. However this may be, it is certain that true alpax, *i.e.*, refined 86.5: 13.5 aluminium-silicon alloy, is a true eutectic. This indicates that the equilibrium diagram, as shown, may be wrong.

It might also very well be asked whether the refining treatment does not also modify the hypo-eutectic alloys. Offhand, it would seem not, and this also applies to the hyper-eutectic alloys in

TABLE IV.—*Theoretical and Actual Density of Three Aluminium-Silicon Alloys.*

Composition of alloy elements, per cent.		Actual density, gms. per c.c.,	Theoretical density, gms. per c.c.
Al*	Si		
98.3	1.7	2.65	2.676
90.4	9.6	2.64	2.67
87.7	12.3	2.63	2.66

* Aluminium by difference.

which free silicon exists as the excess substance. These latter alloys are not useful, incidentally, for mechanical construction purposes. These matters will, however, be discussed more fully in later paragraphs of this paper.

The amount of salts used in refining is small—3 per cent., and it is of interest to state that a small increase in the amount of salts added causes slight diminution in the properties of the alloy.

Mechanical Properties.

Some figures obtained as to the mechanical properties of unrefined aluminium-silicon alloys have already been gives in Tables I to III inclusive. The ordinary results obtained for an alloy containing about 12 per cent. silicon are as follows:—

For Cast Alloy.—Elastic limits, 8.0 tons per sq. in. (12.6 kg. per sq. mm.); tensile strength, 9.9 tons per sq. in. (15.6 kg. per sq. mm.): elongation, 2.2 per cent.; reduction in area, 5.9 per cent.; Brinell hardness, 50.5; and charpy impact resistance, 0.6 kg.-m. per sq. cm.

For Worked Alloy, Annealed.—Elastic limit, 5.1 tons per sq. in. (8 kg. per sq. mm.); tensile strength, 9.7 tons per sq. in. (15.4 kg. per sq. mm.): elongation, 16 per cent.; reduction in area, 37.7 per cent.; Brinell hardness, 46; and charpy impact resistance, 1.3 kg.-m. per sq. cm.

Some data are given in Table V for the mechanical properties of alpax, aluminium, and three common light aluminium alloys, in the cast and worked conditions. Data are not given for the properties of cast aluminium and duralumin. Duralumin does not attain its best properties except when heat treated, and the usual heat treatment applied to wrought duralumin does not give noteworthy results in the case of the cast alloy. As already pointed out, cast substantially pure aluminium has tensile strength of 4.4 to 6.2 tons per sq. in. (7 to 10 kg. per sq. mm.) and elongation of 8 to 12 per cent., or more, depending upon the pouring temperature. As will be noted in Table V cast alpax has the highest strength and elongation of the alloys listed; viz., 11.4 to 14.6 tons per sq. in. (18 to 23 kg. per sq. mm.), with elongation of 5 to 10 per cent. The properties of cast alpax are better than those of the rolled and annealed alloy. While most alloys are, of course, stronger when worked and annealed than when cast, it appears that either mechanical treatment itself or reheating before rolling or other working has a deleterious effect upon the properties of alpax. Whether refined or unrefined, the cast aluminium-silicon alloys have about the same properties as the worked alloys.

TABLE VI.—*Tensile Properties of Samples of Alpax.**

Yield point, tons, per sq. in.	Tensile strength, tons, per sq. in.	Elongation, per cent.	Reduction in area, per cent.
7.1	13.2	7	8
6.6	12.5	9	9
6.9	12.8	8	9
7.6	13.2	8	10
7.7	13.1	7	9
7.2	12.4	10	10

* Tests by Czochralski.

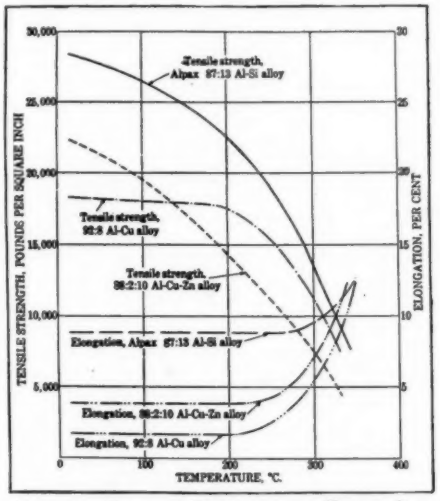


FIG. 5.—TENSILE STRENGTH OF THREE CAST ALUMINIUM ALLOYS, AT ELEVATED TEMPERATURES (CZOCHRALSKI).

Table VI gives the results of some tests made by Czochralski on cast alpax (test bars or castings).

TABLE V.—*Comparison of the Mechanical Properties of Alpax, Aluminium, and Three Aluminium Alloys.*

Composition of alloy.	Cast.			Rolled or drawn.					
	Tensile strength, tons per sq. in.	Elongation, per cent.	Brinell hardness‡	Tensile strength, tons per sq. in.		Elongation, per cent.		Brinell hardness.‡	
				Annealed.	Cold worked.	Annealed	Cold worked.	Annealed	Cold worked.
Alpax, 11.14 per cent. Si* ..	11.4—14.6	5 to 10	60	10.2	19.1	30	5	60	—
92:8 Al-Cu. ..	7.6—19.0	1 to 2	60	12.7	19.1	20	10	60	90
88:2:10 Al-Cu-Zn. ..	7.6—10.8	2 to 4	55	12.7	19.1	20	10	55	90
Duralumin	—	—	—	24.1	26.6	20	15	60	150
Aluminium†	—	—	—	6.4	12.7	30	5	30	60

* Remainder aluminium. † Commercial. ‡ 500 kg. load, 10 mm. ball.

Tests have been made to determine the effect of refining on the mechanical properties of hypo-eutectic alloys, which showed that refining has considerable effect upon all the mechanical properties of the alloys, except upon the strength and hardness of the alloy containing about 5 per cent. silicon.

While it has been shown that the mechanical properties of the aluminium-silicon alloys are quite good at the ordinary temperature, it is of interest to have information concerning their properties at

high and low temperatures. Tests have been made by Czochralski on the effect of increasing temperatures upon the strength of alpax and other aluminium alloys, and Fig. 5 shows the effect of elevated temperatures upon the strength and elongation of cast alpax, 92 : 8 aluminium-copper alloy, and 88 : 2 : 10 aluminium-copper-zinc alloy. Fig. 5 shows that cast alpax maintains strength up to about 350 deg. C. superior to that of the other two alloys. The 92 : 8 aluminium-copper alloy loses very little strength up to 200 deg. C. The elongation of the 92 : 8 aluminium-copper alloy is not much affected up to 200 deg. C., and that of the 88 : 2 : 10 aluminium-copper-zinc alloy up to 240 deg. C., while the elongation of alpax remains constant up to about 260 deg. C. Above these respective temperatures the elongations of the three alloys rise rapidly. It may be pointed out that the mechanical properties of rolled alpax are superior to those of rolled aluminium up to 300 deg. C.

In the matter of the effect of low temperatures upon the properties of alpax, some tests have been made by the writer to determine the hardness and impact resistance at both high and low temperatures. These tests were made on un-notched bars 20 × 20 × 80 mm. Evidently, on the basis of these tests, temperature, whether high or low, within the range indicated, does not have much effect on the impact resistance. Brinell-hardness tests were made on alpax at elevated temperatures. Brinell-hardness tests were also made on the refined and unrefined alloy at low temperatures. Refining apparently has no effect upon the retention or increase in hardness at either high or low temperatures. The hardness falls markedly with increasing temperature and rises markedly with decreasing temperature (*i.e.*, at temperatures much depressed below room temperature).

Data on the frictional resistance of alloys are useful in considering certain practical applications, and the new Jannin machine is useful for making friction tests. Tests have been made, using this machine, of the friction, *i.e.*, resistance to wear, of a series of refined and unrefined aluminium-silicon alloys. Refining does not seem to have much influence on the frictional resistance, but wearing away under the action of friction does, however, increase with increasing percentage of silicon. In the tests lubrication was used: some tests were made without lubrication, but the results were not satisfactory owing to the formation of burrs.

Attention should be directed to the effect of impurities on the properties of alpax. The principal impurity is iron, derived from the original silicon and aluminium. It is essential that the iron content of alpax should not exceed 0.8 per cent., and it should preferably be not more than 0.5 to 0.6 per cent., since otherwise the elongation is seriously reduced. The copper content should preferably be not more than 0.5 to 0.6 per cent., since otherwise elongation again falls off. Investigation of the effect of other impurities has not been made.

(To be continued.)

Melting White Bearing Alloys.

BY "CELSIAN."

Although numerous articles have been published on the wear, corrosion and general application of white-bearing alloys, few, if any, deal with the methods adopted for making the metal. The economical aspects of the question are seldom considered from a practical standpoint, and as a rule, the most information to be derived from the average book on alloys is that they are made up from tin, lead, antimony, and sometimes copper. Melting white-bearing alloys requires probably as much, if not more experience than that necessary in the preparation of alloys of a much higher melting point. The amount of scrap which can be utilised in this work is considerable, and unlike many other alloys, certain bearing metals can be made entirely from scrap. The kettles or melting pots originally employed for this work were mostly coal-fired, as accuracy in raising the temperature was considered of secondary importance. Of later years gas-fired melting kettles have largely superseded the former type. The gas-firing permits the control of the heat to be easily supervised by comparatively unskilled labour. Although pyrometers are to be recommended for this work, few of them are used in actual practice, and rule-of-thumb methods till predominate. This often accounts for serious losses being experienced when white alloys rich in copper are manufactured. Moulds for casting ingots of white metal (usually made of thin cast iron) are covered with a thin layer of grease prior to pouring the molten alloy. As compared with other alloys, the melting loss incurred in making bearing metals is very slight, as the temperatures employed should not be sufficiently high to cause volatilisation to occur. Losses are more likely to be incurred with too cold metal, as pieces of the solidified mass require to be remelted with fresh scrap.

Economical Methods of Manufacture.

The manufacture of white-bearing metals is seldom conducted so economically by engineers as by metal refiners. The latter prepare their metal from different varieties of scrap, whereas the former use the virgin metals, as a general rule. Refiners and some brass founders use mixtures of white-metal borings, skimmings, drosses and scrap, and sometimes type metal scrap. After this has been melted up in a kettle a sample of the metal is analysed and then brought up to the correct composition by the addition of scrap lead, antimony and solder, or other scrap alloys of these metals.

Fluxes are seldom added when the virgin metals or scrap are being melted, though they are usually protected from the oxidation of the atmosphere by a layer of grease or cheap oil. Zinc chloride is sometimes added to clean the oxide off the surface of the molten metal, but it is not a flux to be recommended as some of the zinc may combine with the white metal. In certain cases metallic sodium is added as a deoxidiser, improving the appearance, grain and homogeneity, but impairing the toughness and hardness of the metal.

In making up the alloy from new metals, the lead is melted first, then the antimony or antimony-lead alloy. Part of the tin is added, and then the remainder, together with the copper as an alloy of copper, tin, and a little antimony. The latter is prepared by melting up the metals in plumbago crucibles in an ordinary pit fire. After stirring well, the metal is skimmed and poured into iron ingot moulds. When dealing with alloys of tin, lead, and antimony, the metal should be poured at as low a temperature as possible, but when much copper is present the temperature must not be too low or part of it will be removed on skimming. After pouring, the metal in the mould is again skimmed with a small strip of iron before it solidifies.

When melting out white metals from skimmings, drosses, dirty borings, etc., the flux used consists of a mixture of 30 parts of potassium ferrocyanide, 20 parts of soda ash, and 10 parts of borax. This is added a little at a time, to the waste material, in a kettle. The residual ashes are skimmed off the surface and sold to large brass-founders, who recover the remaining metal by either washing in the concentrating plant or smelting in large furnaces.

Regarding the latest types of white-bearing metals, those containing a percentage of bismuth are much too costly at the present time to be adopted universally. The addition of nickel for the purpose of hardening is little short of a fad, the only real value of nickel being its property of stopping segregation. Considerable experience is required in the making up of white metals containing nickel, since there is such a wide difference between the temperatures of the metals employed.

Nickel is usually introduced as nickel tin when the white alloy has reached a fairly high temperature. Alloys for the bearings of ships' propellors sometimes contain several per cent. of mercury. This is added with a view to making it resist corrosion, but the cost of the alloy is so high that it is not likely to become a metal of great commercial importance in the near future.

MEMBERS of the graduate section of the North-East Coast Institution of Engineers and Shipbuilders visited the works of the Team By-Product Coke Company, Limited, Dunston, on Saturday last, Mr. W. Campion (works manager) and Mr. J. Curry (coke ovens manager), receiving the party.

Institute of British Foundrymen.

The Lancashire Branch Annual Dinner.

The annual dinner took place on Saturday, February 7, at the Grand Hotel, Manchester. There were present 121 members and friends. The chair was occupied by the Branch-President, Mr. R. A. Miles, and among the guests were the President of the Institution, Mr. R. O. Patterson; Mr. Herbert Bates, the President of the Manchester Association of Engineers; Mr. A. P. M. Fleming, Past-President of the North-Western Centre of the Institution of Electrical Engineers; and Mr. H. E. Stone, President of the Manchester Junior Gas Association.

The Broad Lines of Research.

After the toast of "The King" had been honoured, MR. A. P. M. FLEMING proposed the toast of "The Institute of British Foundrymen." He said it struck him as remarkable that a vocation or trade which was one of the oldest arts practised in modern industry was represented by an Institute which had just reached its 21st year. But perhaps it was fitting. Certainly he hoped that the Institute, and the members also, would always be young in heart. Men who belonged to older institutions were perhaps inclined to sit back in their armchairs and rest on their laurels, content with what they had done in the past, but a young Institute must have progress for its motive and be always looking forward.

Sometimes one had a feeling that development was coming to an end, that all the great inventions had taken place, and saturation point had been reached. A little reflection would remove that mistaken idea. It would recall to their minds how extremely rapid the development had been, and all along the line progress was continuing. Additions were constantly made to our stores of knowledge, and were applied in every branch of industry. That with which he was closely associated, the electrical industry, was a remarkable example. Unknown a hundred years ago, it had now ramified into every kind of activity, and called for all the energy of which man was capable. Yet no sane person could even imagine that the saturation point had been reached in its development. Indeed, in the future progress would be at a more rapid rate than in the past. He thought similar things could be said of every branch of industry.

On what lines would progress proceed? What were the principal factors in it? In his opinion there were two essential factors. One was the development and application of new knowledge. Sometimes that was spoken of as research, a term people were sometimes very sick of hearing and sometimes a little afraid of. To his way of thinking it could be interpreted very simply. He looked upon industry as being the means by which something taken from Nature's resources was transformed, it might be through very complicated processes, into something useful to mankind. In foundry work they took a product of the earth and began a series of processes the result of which eventually showed itself in the form of trains, ships, cars and a multitude of other things used by man. Anything which contributed to making that transformation more complete, more efficient than it otherwise would be was a legitimate field for research. It might be simply a matter of developing and applying new knowledge in order to make one's work more effective and more efficient; from that point of view they were all engaged in research in some degree. When done systematically, it was scientific research. Now, whatever their opinion was of particular methods by which it was sought to apply that knowledge, whether the work was done in their own foundries, or by independent people, or by Associations, they were all agreed that there was a need of it, that it marked the path of progress, and that without it any business must decline

One form of research might have a far-reaching effect on the foundry industry. He referred to the work of the scientist and the physicist. In various parts of the world that work was being prosecuted, and during the last twelve months, having had occasion to consult the leading physicists, he had been struck with the fact that so many of them were working along the lines of determining the constitution of matter as revealed by the study of the structure of the atom. It sounded a very far cry to associate the structure of the atom with the business of producing sound castings at a cheap price, but he could assure his audience that the distance was not so great as it seemed. He was convinced that, as a result of the work now going on in the Cavendish laboratory at Cambridge, and in other laboratories in Germany and the United States, there would be, during the next few years, a light thrown upon the constitution of matter and its effect upon the properties of materials which would illuminate the path along which people were now groping with great difficulty and almost blindly. It was worth while to keep in mind the possibilities along those lines.

The second essential factor in the progress of an industry was the personnel. That was a matter which, in his own industry, had interested him very greatly during many years past, particularly the methods of dealing with the young people engaged in it. It had been said that no Church work was healthy unless provision was made for capturing the young and setting them to work. So also with an industry. He believed much could be done with the foundryman if he was caught young. It was particularly pleasing to him to learn that one of the important features of the work of the Institute was the attention given to attracting the best type of youths and making the best provision possible for their training. He was sure those were the right lines.

It was seldom realised just what an Institute meant to the members who constituted it. One might question the wisdom of great combinations of industrial works and wonder whether such combinations would make the product cheaper or bring a bigger dividend to the shareholders, but there could be no doubt about the advantages and the desirability of a combination which consisted in men getting together in their professional institution for the purpose of discussing their problems and difficulties and helping one another, of guarding the interests and developing the intelligence of the people engaged in the industry. He was sure that none of them adequately realised how important it was to them, not only individually but collectively, to support the Institute in its work. In particular the question of the young people called for attention. It was a good sign that leading employers throughout the country were taking more kindly interest in the young people they employed; it augured well for the future of the industry, and of the Institute in particular.

Foundry Realities and Requirements.

MR. R. O. PATTERSON, President of the Institute, responded. He said they were all proud of the Institute and had good cause to be so. Though it was only 21 years of age, the work done in that short time was really remarkable. There was still a tremendous field for work in front of them. At a meeting of the Branch that afternoon a talk took place upon the subject of the foundry apprentice. Perhaps some people were getting rather tired of that subject, but remembering that the whole future of the industry would depend upon the apprentices, it was evidently a very serious question to which attention must be given. They all knew that the foundry was not an attractive place; it was dismal and dark, and the work was laborious. Yet it required the exercise of the greatest skill, and the moulder was admitted to be, as a rule, an artist, to be classed apart from the ordinary workman. Every endeavour should be made to cut out the laborious part of the work, and for that reason he welcomed the introduction of moulding machines. The more they did on those lines the better the conditions were for the

men, and there would be a corresponding improvement in the class of men who came into the foundry.

With regard to the men, a little humanity in the treatment of them was called for. He believed that in small foundries where the manager or foreman was in daily touch with the men, the conditions were perhaps better and fairer than those which obtained in large foundries employing hundreds of men. At one time a man was considered a good foreman or manager for a foundry, no matter how little technical knowledge he had, if he was a good driver; but that state of things was passing.

They required foundrymen to be in the industry from inclination, and to take an interest in their work. A little study would show that it was most interesting. As Mr. Fleming had said, it was the oldest of trades, going back to the time of Tubal Cain. Why had it not stood on a higher plane? In his opinion, it had been largely a matter of L. s. d. It was unfortunate that the price of castings depended on the man who had last set up in business, possibly in a backyard, who had no standing charges, subscribed to no societies, did nothing to help the trade along, but was only out to make a living for himself. That was very unfair competition to be overcome by firms who were doing their utmost to push the industry along; who developed knowledge, and paid for it.

However, notwithstanding the particularly evil times which the industry had gone through during the last few years, it was getting along well, though its progress was not as fast as he wished. The Institute was the parent of the Cast Iron Research Association, which was now doing particularly good work. Such an Association had been needed for many years. They wanted light to be thrown on subjects connected with the industry, and they expected the Cast Iron Research Association to supply that light. The work had to be paid for, and a comparatively small number of firms were now paying for it. Under its present direction the Association was making rapid progress, and he looked forward to seeing an immense amount of valuable work done for the benefit of the foundry trade in general.

Sympathy with Mr. Hollingworth.

MR. OLIVER STUBBS, Past-President of the Institute, said many of those present were aware that Mr. Hollingworth, the Secretary of the Institute, had been ill for a long time, and he was sure they would allow him to send him their deep sympathy and their earnest wishes that he would soon return amongst them.

Kindred Associations.

MR. STUBBS proceeded to propose the toast of "Kindred Associations," naming the Manchester Association of Engineers and the Manchester Junior Gas Association. He said foundrymen were very much dependent on engineers, from whom they expected good designs and good patterns. Those would help them materially to give good castings in return. There must be united effort. Unless they worked together they would not come to the happy conclusion they hoped for. He was glad to say that arrangements had been made for meetings when engineers and foundrymen met on common ground to discuss the problems in which they took mutual interest.

The Manchester Association of Engineers was established in 1856, and it had numbered among its members men of eminence like Sir Joseph Whitworth, and a Paper now included in the Proceedings of the Association which gave particulars of many of the past members set forth a list of which the present generation had reason to be proud.

He believed Mr. Stone would agree that their friends in the gas industry were very much dependent on the foundrymen who supplied them with cast iron. In return, foundrymen looked to them for the production of a commodity of which considerable use was made in foundries, but which he believed had fallen very much in value from the heating point of view. That was gas.

MR. HERBERT BATES said he belonged to many Associations connected with engineering. He joined one as a student, and received a great deal of benefit from it: at the first opportunity he joined the Manchester Association of Engineers, and after many years of membership he had been given an honour of which he was proud in being selected to be its President. The Association was formed some 68 years ago by a number of foremen and draughtsmen, and great efforts had always been made to maintain a very high standard of membership. In the old days questions were raised in a very practical form, the debates being carried out by the foremen without any preparation, merely comparing notes. Now, of course, the proceedings were on more scientific lines. Changed conditions had brought about specialisation, and there were now many Associations of Engineers, and perhaps the establishment of the Institute of Foundrymen might be regarded as also the outcome of that tendency.

These Associations and Institutions were now taking up the work of research which at one time was confined to firms who had large establishments and could afford to put aside large sums to meet the cost of investigations in connection with the manufacturing processes they were engaged in. The work of the Associations and Institutions was of very great benefit to firms who could not spend their capital in this way. As an instance of what was being done, he might mention that his Association had instituted some very important research work in connection with high-speed steel, its hardening operations and cutting properties. The Institution of Mechanical Engineers had carried the work further. His audience would agree with him that nothing would do more to keep this country at the head of engineering throughout the country than the encouragement of such Associations, which brought together men in the same industry for the purpose of discussing industrial problems for their mutual benefit.

MR. HAROLD E. STONE said as the gas industry was very dependent upon the products of the foundry for such purposes as the distribution system, which was carried out by cast-iron pipes, they could appreciate the work which foundrymen did, and the merits of an Institution like the I.B.F. Research work was called for in every industry, and it was one of the functions of such an Institute to encourage and assist those who were engaged in it. One field for it was in connection with heat-resisting castings.

Presentation of Diplomas.

MR. R. O. PATTERSON presented to four members of the Lancashire Branch diplomas which had been awarded to them in respect of papers read by them. The members were:—Mr. A. L. Key ("Jolt Ram Moulding Practice"), Mr. S. G. Smith ("Manufacture and Characteristics of Cast Iron"), Mr. F. W. Rowe "Selection of Pig-Iron for High-Grade Castings") and Mr. A. Sutcliffe ("Dry Sand and Loam Moulding").

The American Foundrymen's Visit.

THE CHAIRMAN announced that an illuminated address had been received from the American foundrymen who visited this country in 1923, and desired to show in this way their appreciation of the hospitality extended to them by the members of the Lancashire Branch. The Council of the Branch had obtained permission from the authorities of the Manchester College of Technology for the address to be hung up in that building near the room where the meetings of the Branch were held.

The Lancashire Branch and its President.

The toast of "The Lancashire Branch and its President" was proposed by Mr. V. C. Faulkner, Junior Vice-President of the Institute. He observed that the Branch had nearly 300 members, and it had also enrolled about 250 students. It was the largest Branch of the Institute, a very creditable achievement seeing that there were other areas of equal importance considered from the foundry point of view.

Mr. Fleming had said anything which helped in the transformation of metals, up to the point of making it into useful entities, constituted a subject for research. What was the most necessary thing to do to raise the industry to a higher plane? It was in the hands of the people engaged in the industry. It was not altogether the affair of the Institute, but it could be done through

employers' federations. Sooner or later there must be a unified system of costing. No one knew better than they that the prices of castings in this country were governed by the last foreman who set up in business for himself in a backyard.

He was surprised the President of the Institute had not made reference to cast-iron roads. They were simply a series of cast-iron shells filled with concrete, and if they could be substituted for the pavements over which some of those present would have to pass that evening it would be doing Manchester a good turn. He associated with the toast their Branch-President, whose popularity was indicated by the fact that he had occupied the chair for a second term of office.

THE CHAIRMAN said this was the second occasion on which he had had to respond to this toast. He could say that a large amount of work had been done, and in the establishment of the Junior Section they felt that a very important step had been taken in the movement which would become national and result in the Institute taking over the control of all the Junior Sections. In connection with it, they had received great assistance from foundry employers, particularly from Mr. Oliver Stubbs, and the Section was now second to none in the country.

During the evening a musical programme was rendered.

Condition of the British Iron and Steel Industry.

Mr. Pugh on Competition.

At the recent meeting of the Committee on Industry and Trade evidence was submitted by Mr. A. Pugh, on behalf of the Iron and Steel Trades Confederation.

Mr. Pugh first dealt with the present position of overseas trade in iron and steel and its prospects in relation to employment and the standard of living of the workers in the industry. The industry depended upon its export trade to the extent of not less than 60 per cent. of the total output, he said, and this country's proportion of the world trade in iron and steel had been increased as compared with the 1913 position, since the British share of the total exports then was 30 per cent., and in 1923 34 per cent. In regard to competition in the home market, foreign imports in the years 1920 to 1923 had borne a much lower relation to those of 1913 than our exports had done to the same year, but it seemed certain that this would not apply to 1924. On the whole, the British iron and steel industry had succeeded in maintaining its position in relation to the world trade, and it was necessary to look for other causes of the high rate of unemployment and of the unsatisfactory financial returns experienced, particularly in the heavy branches of the industry.

He suggested that during the past 3½ years production had been maintained only at material sacrifice on the part of the producers, both employers and employed. He thought that the reduced purchasing power of the world and the depressed condition of shipbuilding and engineering were the main factors which had operated against the prosperity of the iron and steel industry. Further, so far as unemployment was concerned, the recent extension of steel plant in the country had led to greatly increased productive capacity, requiring fewer workers to manipulate it. For example, the numbers employed in steel melting and rolling had decreased in 1923 by 34 per cent., but the output per man had increased by 37 per cent. A similar position existed with regard to blast-furnace plants.

Distributing Costs.

Mr. Pugh submitted that attention should be given to the excessive cost of distribution of finished products, and that, in view of the effect of adverse exchanges, low economic standards of competing countries, foreign trade subsidies, and dumping, there was room for a Government policy, including international arrangements whereby the more progressive countries undertook to protect themselves against countries with low economic standards. He urged that attention should be given to the policy of the middleman and its effect upon national economy, and to the necessity for the public to receive a full account of their stewardship from those who controlled industries.

Turning to the ability of the industry to meet competition, its productive capacity, the efficiency of capital, labour, and management, and the problem of raw materials, Mr. Pugh gave particulars of recent developments of plant in the various branches of the trade, and submitted that, while there had been considerable improvement, there was room for still more in many directions. The new construction which had taken place had largely affected the finances of the companies concerned, and, in addition, during the "boom" period 1919-20, there had been numerous changes in organisation involving the purchase of share capital or of entire businesses, generally at very high prices. In certain cases also firms had found it possible to revalue their undertakings and nominally to increase their capital by the creation of bonus shares. The consequence of all this was that at the present time the industry was over-capitalised, from which position relief was necessary to place the industry on a fair competitive basis, both in the world and in the home markets.

Efficiency of Labour.

On the question of labour efficiency, the introduction of the eight-hour shift had undoubtedly increased the output per man, better works organisation, better material, and means of heating having also contributed to increased output. The effect of all recent developments had been to throw more responsibility upon the skilled and semi-skilled workmen, for whom it might justifiably be claimed that they had proved equal to the demand made upon them. As regards the managerial side, it was felt that the managerial, controlling and supervising ranks were to some extent overloaded, the result in some cases of amalgamation of businesses. There was still room for more efficient internal works organisation, and the training of managerial units was not sufficiently provided for. Works managers should be left free to concentrate upon the attainment of the maximum production with the minimum waste of material and human energy.

In addition, Mr. Pugh suggested that expert attention should be given to the position in regard to the supply of raw materials, and that national electrical development and its application to the railway system should be encouraged with a view to cheapening distribution. He felt that a system of pooling of orders would lead to a reduction of costs of production, and that a joint and co-operative marketing organisation, which should have for one of its objects the discovery of probable world demand, might enable some of the costly services of middlemen to be dispensed with. He also submitted that steps should be taken in regard to the handicaps imposed on productive industry by obsolete land laws and charges for wayleaves, royalties, etc.; and that technical training, scientific research and invention should be encouraged.

Wages and Negotiations.

Finally, Mr. Pugh dealt with wages and industrial relationships. After stating that the iron and steel industry was substantially a piece-rate industry, and explaining the system of basis-rates and sliding scale percentages (based on selling prices) on which wages were calculated, he pointed out that, owing to the present depression, wages in the industry generally had risen above pre-war figures to a substantially smaller extent than the cost of living. The methods of negotiation in force in the trade were then explained.

The negotiating machinery of the industry had been highly successful in avoiding strikes and lockouts, a success which Mr. Pugh attributed to the complete recognition of trade union organisation and of the right of collective bargaining, unequivocal observance of agreements, and the mutual acceptance of the principle of arbitration as a final resort in the settlement of disputes. While this system had been successful Mr. Pugh suggested that, as to the future, regard must be had to the fact that education, the political franchise, and developments in the industry itself were creating a new viewpoint on the part of the average intelligent workman, who showed an increasing tendency to demand more information concerning the affairs of the industry in which he was employed. He saw no final solution to the problem of industrial strife, except a different conception of the true purpose and functions of industry, involving a higher standard of education in civic and social responsibilities on the part of all concerned and fundamental changes in the system itself.

As a preliminary step Mr. Pugh suggested the establishment of organisations of workpeople and employers respectively, competent to speak for an industry as a whole, the setting up of complete machinery for joint negotiation, and a joint central council dealing with matters of common concern relating to the welfare of an industry. The application of such an organisation to all industries should do much to lessen industrial strife. The system of open inquiry into disputes which an industry fails to settle should be also developed. He suggested the establishment of a national industrial council, and thought that such a body would have a valuable function in consulting, advising, and initiating in regard to matters of national industrial policy.

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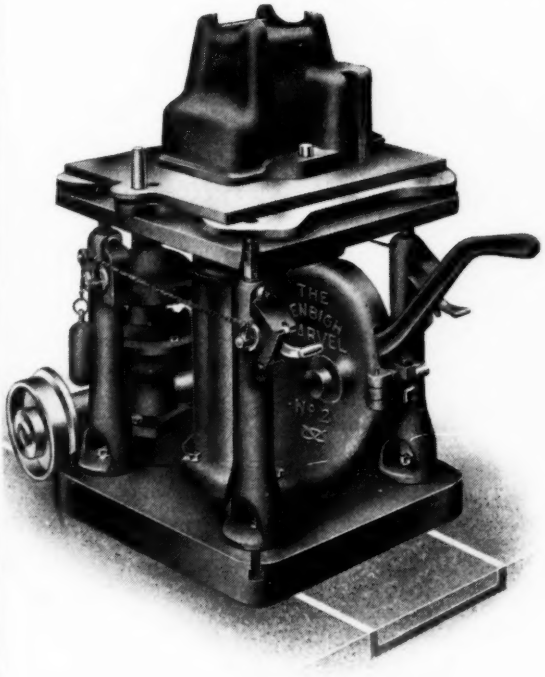

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Trade Talk.

BOWKETT BROS., wire drawers, have removed to St. George's Street, Snow Hill, Birmingham.

WILLIAM BAIRD & COMPANY, LIMITED, of Glasgow, have decided to blow out seven blast furnaces.

THE EBBW VALE IRONSTONE MINES in Northamptonshire, after being closed down for two years, are to be re-opened during the present month.

THE NEW FURNACE at the Renishaw Ironworks of the Renishaw Iron Company, Limited, Chesterfield, which was finished last November, was put into blast last week.

CONSIDERABLE DAMAGE was done at the Port Clarence Works, near Middlesbrough, of Dorman, Long & Company, Limited, on February 5, by an outbreak of fire, which gutted the pattern shop and store and the joiners' shop.

THE CONTRACT for the new paper mill of the Wayagmack News, Limited, Three Rivers, Quebec, Canada, stipulate that the whole of the steel should be of British manufacture. The new undertaking will consist of three large buildings, 467 ft. by 134 ft. by 48 ft. 6 in., 167 ft. by 100 ft., with annexes 62 ft. by 54 ft., and 119 ft. by 85 ft. 2 in. by 38 ft. 6 in. respectively. Over 1,000 tons of steelwork are required for the framing, and John Booth & Sons, Hulton Steelworks, near Bolton, who have secured the contract, have to ship the whole in the remarkably short time of 12 weeks. An interesting transport problem is presented in connection with one of the girders for the wood pulp mill, which is 53 ft. long, weighs 25 tons, and will be shipped across the Atlantic in one piece.

MR. ARTHUR DORMAN, of Dorman, Long & Company, Limited, in an interview with a representative of the "Financial Times," said that the exports of iron and steel last year were 1,100,000 tons less than in 1913 and 500,000 less than in 1923. On the other hand, imports had increased. Last year they were 2,000,000 tons greater than in 1913 and 1,000,000 tons greater than in 1923. Asked what was the remedy for this position, Mr. Dorman replied, obviously cheaper production. Consumers generally, and especially re-rollers, should from their own point of view use more British steel and the British steel-makers would no doubt help to the extent of arranging a reduction in prices. By so doing, the output would be increased at a decreased total cost. This would prove an advantage to the manufacturer, who would be better able to compete in the foreign markets. It would also be to the advantage of re-rollers to use British steel, although they might have to pay a little more.

"IT IS MY DELIBERATE opinion that unless we get Protection we shall witness the death of the steel trade in this country, as we understand it to-day." In these terms Mr. Benjamin Talbot, managing director of the Cargo Fleet Iron Company, Limited, and the South Durham Steel & Iron Company, Limited, expressed to a "Yorkshire Post" representative his conviction that the iron and steel trade should be included in the scope of the Government's plans for an extension of the Safeguarding of Industries Act. He viewed the present position of the industry with serious apprehension. Steel must ultimately be made from pig-iron, for the quantity of scrap material—now that the war scrap was practically exhausted—was comparatively small. Whereas in 1913 we had a surplus of pig-iron over steel ingots of approximately 2½ million tons, which was required for the engineering and forge trades, in 1924 there was a deficiency of 900,000 tons in the tonnage of pig-iron compared with steel ingots produced. There was no surplus at all of British pig-iron for the engineering and foundry trades. What had happened, of course, was that the difference had been made up of imported pig-iron and accumulated war scrap. No country, continued Mr. Talbot, could hope to be a large steel maker, as now understood, unless it produced pig-iron and steel ingots. "For these reasons I am in favour of an application by the steel trade to the Government for protection under their Safeguarding of Industries Act proposals," stated Mr. Talbot. He believed that the business results would be much better than are now secured under so-called Free Trade. If the industry began to decline, as he feared it would, if the existing conditions continued, his action as a steel producer would be to become a re-roller of steel. This would involve the closing of the blast furnaces and steel furnaces. Such a step would be a very serious one for the railways, which now carried seven tons of material for every ton of steel produced. If he was compelled to become merely a re-roller of steel, the imported material would be landed at the works' own wharf, and the railway companies would only handle the finished product. This step would not only mean less work for the railways, but a big reduction in the number of men at present employed in the steel trade in this country, as all the furnace plant would be closed down.

Personal.

SIR ARTHUR DORMAN sailed for Australia on Saturday last.

MR. S. Y. STROH, of Pittsburgh, the inventor of the Stroh process of making steel castings, has arrived in Europe and is staying at the Royal Victoria Hotel, Sheffield.

MR. SAMUEL SUTCLIFFE, who has had 40 years' association with the Darwen & Mostyn Iron Company, Limited, has been the recipient of a presentation from the officials and men upon his election as managing director of the company.

MR. A. GOODWIN, of C. A. Vandervell & Company, Limited, has been elected chairman of the Accessories and Components Manufacturers' Committee of the S.H.M.T., vice Mr. W. Peto, who has held this position for the past four years.

Contracts Open.

Ashford, February 23.—(a) Three 400-kw., three-phase, 50-period, 6,600-volt alternators, 250 r.p.m.; and (b) 15 e.h.t., 6,600 volts switchgear cubicles, for the U.D.C. Mr. H. Wilson, electrical engineer, Ashford U.D.C., 11, Bank Street.

Edinburgh, February 28.—Fifty cast-iron root pillars (approximately 2¼ cwt.) from pattern supplied, for the Corporation. Mr. A. Grierson, town clerk, City Chambers, Edinburgh.

Horsforth, February 28.—(a) 6-in., 4-in., 3-in. cast-iron water mains and specials, or, alternatively, spun iron pipes or concrete-lined pipes; (b) valves and hydrants; (c) valve and hydrant covers and gully grates and frames, for the Horsforth U.D.C. Mr. J. E. Aldersley, surveyor, Council Offices, Horsforth.

Liverpool, March 10.—Materials, etc., for period covering 12 months ending March 31, 1925, for the Town Council. The City Engineer, Municipal Buildings, Dale Street, Liverpool.

Prees, Salop, February 23.—(1) The provision and laying of 3,500 yards of 4-in., 3-in. and 2-in. cast-iron pipes, and 2,000 yards of 1-in. galvanised-iron pipes, with valves, hydrants, stand-pipes, etc.; (2) building 20,000-gallon concrete reservoir; and (3) building pump-house at Prees, for the Wem R.D.C. The engineer, Mr. W. W. Wyatt, Whitchurch, Salop. (Fee, £2, returnable.)

Southend-on-Sea, February 19.—About 100 tons of cast-iron pipes and specials, 9 in. diameter to 18 in. diameter, of British manufacture, for the Corporation. Mr. R. H. Dyer, borough engineer and surveyor. (Fee, £2, returnable.)

Company News.

James Stott & Company (Engineers), Limited, Vernon Works, Lee Street, Oldham.—Capital £7,000 in £1 shares.

Westinghouse Brake & Saxby Signal Company, Limited.—Net profit, £17,193; brought forward, £1,168; dividend, 3d. per share; carried forward, £5,582.

Teasdale & Metcalfe, Limited, 2, North Street, Wetherby, Yorks.—Capital £2,000 in £1 shares Engineers Directors: J. A. Teasdale, J. E. Metcalfe and R. Findlay.

Thomas Shaw (Lian), Limited.—Capital £5,000 in £1 shares. Iron manufacturers. Directors: J. S. Shaw, 3, Eversley Place, Halifax, and P. V. Crossley, 5, Eversley Place, Halifax.

Deptford Star Foundry, Limited, 301, Rolt Street, Deptford.—Capital £1,500 in £1 shares (500 10 per cent. cumulative preference and 1,000 ordinary). Directors: S. P. Hutton and F. K. Webster.

Volatile Metals Extraction Company, Limited, 46, Queen Victoria Street, E.C.4.—Capital £3,000 in 2,750 10 per cent. participating preference shares of £1 and 5,000 ordinary of 1s. Directors: E. Hayes and A. E. Buck.

Burnell & Company, Limited.—Net profit, £29,241; debit balance brought in, £191; preference dividend for 3½ years ended December 31, 1924, at 6 per cent. per annum, £16,796; reserve for preference dividends, £852; carried forward, £11,401

John M. Terry & Company, Limited, 5, Great Hampton Street, Birmingham.—Capital £1,500 in £1 shares (1,000 ordinary and 500 7½ per cent. cumulative preference). Machinery makers. Directors: J. M. Terry and S. J. Tomkins.

J. M. Pirie & Company, Limited, 1, Victoria Street, Westminster, S.W.1.—Capital £20,000 in £1 shares (5,000 6 per cent. cumulative preference and 15,000 ordinary). Architectural metal workers. Directors: J. M. Pirie, W. T. W. Birts and A. E. S. Stokes.

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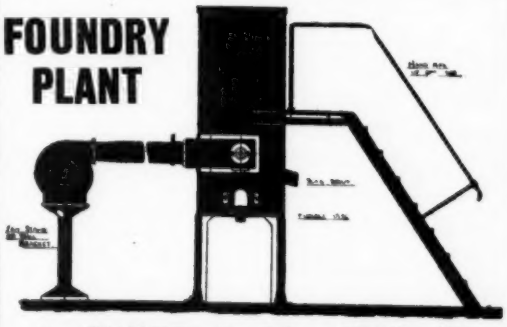

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Contrary to the optimistic expectations voiced a few weeks ago, business in the Cleveland iron trade retains its inactivity, the anticipated revival of buying in the home trade having altogether failed to materialise. It would seem that buyers are not yet convinced that bottom has now been touched, but apart from that, work has not been coming forward to the foundries at all freely of late. Hence consumers are inclined to hesitate before committing themselves further. In the export trade, the outlook is, perhaps, rather more favourable. The recent report that some 2,000 tons of foundry iron had been shipped to America gives point to the fact that a good many inquiries are still coming to hand from that quarter. There is, however, a fairly steady and rather better prompt business passing in small lots, and parcels are changing hands up to about 500 tons. Generally speaking, sellers are not disposed to take a pessimistic view, and on 'Change this week the previous week's quotation for No. 3 G.M.B. was firmly held at 79s. per ton. No. 1 was 84s., No. 4 foundry 78s., and No. 4 forge 77s. per ton.

The Tees-side market for hematite continues quiet, with values a shade weaker, East Coast mixed numbers quoting down to 86s. per ton. On the West Coast prices are unchanged, Bessemer mixed numbers being quoted at 95s. c.i.f. for Welsh ports, 98s. 6d. per ton delivered at Glasgow, 102s. 6d. per ton delivered at Sheffield, and 105s. per ton delivered at Birmingham.

LANCASHIRE.—With the foundry industry in the district still inactive, the demand for this quality pig continues on a limited scale, prices consequently having a weakening tendency. At Manchester it has been openly stated that Derbyshire No. 3 can be bought at the furnaces at 82s., but this is not the limit of the concessions, and it is rumoured that sellers of Derbyshire would not now refuse orders at 87s. at the furnaces, or, say, 88s. 6d. per ton delivered in this district.

THE MIDLANDS.—In South Staffordshire and the adjacent districts, also, the prices for foundry pig are easier, with only a restricted demand, quotations ruling as follow:—Derbyshire No. 3 foundry, 80s. to 82s. 6d.; Staffordshire No. 3 foundry, 82s. to 85s.; Northants, No. 3 foundry, 74s. to 75s.

SCOTLAND.—As evidencing the depressed condition of the local smelting industry, it is announced that one of the largest pig-iron producers in the West of Scotland has decided to immediately close down his entire furnace plant. Inquiries in Glasgow market are restricted to small lots, with quotations easy at 89s. f.o.t. furnaces.

Finished Iron.

Conditions in the various branches of the manufacturing industry indicate no improvement in the general position, the demand for finished material, with the solitary exception of marked bars, remaining as disappointing as previously reported. The exemption of the last-named may be accounted for to some extent by the fact that the wagon works have been giving out good orders during the last few months for iron of this quality, but it is reported that orders are being worked off rapidly, and that there is not a great deal to take their place. The quotation for marked bars is still £15 at makers' works, and the makers experience no difficulty in getting this figure Local manufacturers are unable to compete with foreign offers for nut and bolt iron, their figure being nearly £4 per ton dearer than the Belgian and French product, and it appears highly improbable that crown iron will be required in as great bulk as formerly, owing to the fact that steel is being utilised in its place.

Steel.

At Sheffield the outlook in the steel industry is reported to be slightly improved, especially in acid billets and ingots, transactions in which are on a very satisfactory scale. Some additional furnaces for the production of this material were put into operation two or three weeks ago, and these are all fully employed. Basic billets are on the quiet side. Siemens acid billets, which are most in demand, are £11 10s. In basic billets, soft qualities are £8 to £8 10s. per ton, medium £8 15s. to £9, and hard £9 5s to £9 10s., delivered. A distinct falling off in wire rod orders is reported, but so far prices remain at £11 to £11 10s. for soft basic, £13 15s. for medium, £15 for hard, and £18 for acid. The makers of tinplates have reduced their basis price to 23s. per box, with a view to meeting the keen competition in the trade. Otherwise conditions in the trade remain unchanged.

Scrap.

Business in this class of raw material has developed further weakness, with both buyers and sellers apparently holding off the market until more settled conditions are assured. The ironfounding trade in Lancashire is doing only a comparatively small business; consequently dealers in cast scrap are not finding a ready outlet for this material, and although it is not openly admitted that prices are lower, yet it is fairly certain that some dealers are accepting less than 85s. per ton for good broken cast scrap; in fact, it is rumoured that this material can be bought as low as 80s. per ton delivered. In Scotland, machinery cast-iron scrap is also quiet at 90s. per ton, and for ordinary quality to the same specification, i.e., pieces not exceeding 1 cwt., 5s. per ton less. Old cast-iron railway chairs are being quoted at 87s. 6d. to 88s. 6d. per ton, but with little business. Light cast iron and firebars still maintain their price at 75s. per ton, and if mixed with firebars about 2s. 6d. per ton less The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Influenced by rather easier American advices and freer offerings in the market, standard values for both cash and forward have developed a weaker tendency, with only a moderate business passing. There was another considerable increase of, roughly, 3,000 tons in the home stocks in the past month to 41,479 tons, this including over 4,000 tons of refined copper, which was certainly not a strengthening feature, and tended to encourage bear operations; but the speculative position was ostensibly oversold, and this is telling now on sentiment.

Current quotations:—*Cash*: Thursday, £65; Friday, £65 2s. 6d.; Monday, £64 17s. 6d.; Tuesday, £64 7s. 6d.; Wednesday, £64.

Three Months: Thursday, £66; Friday, £66 2s. 6d.; Monday, £66 17s. 6d.; Tuesday, £65 7s. 6d.; Wednesday, £65.

Tin.—The market for standard metal has recently indicated a somewhat firmer tone, with values steady for both positions, notwithstanding considerable profit-taking operations. It is now reported to be within the realm of possibility to increase the existing Bolivian output by 2,000 to 3,000 tons in 1925, but this increase (none too certain at best on account of lower tin content of ore mined) is likely to be offset by a decrease at other producing centres, so that the world's total supplies will, in all probability, be no larger than in 1924.

Current quotations: — *Cash*: Thursday, £263 17s. 6d.; Friday, £264 12s. 6d.; Monday, £263 15s.; Tuesday, £262 15s.; Wednesday, £262 5s.

Three Months: Thursday, £267 2s. 6d.; Friday, £267 15s.; Monday, £266 12s. 6d.; Tuesday, £266 15s.; Wednesday, £265 5s.

Spelter.—Producers of this metal generally, being fairly well sold, and, moreover, maintaining a confident view with regard to the future of the market, have shown no disposition to effect sales. Consumption is fairly well maintained, and the relative positions of supply and demand are satisfactory.

Current quotations:—*Ordinary*: Thursday, £36 10s.; Friday, £36 7s. 6d.; Monday, £36 12s. 6d.; Tuesday, £36 10s.; Wednesday, £36 7s. 6d.

Lead.—The market for soft foreign pig indicates some slight improvement, with a tendency to firmer values, due in a measure to an increase in consumptive demand, both at home and on the Continent.

Current quotations:—*Soft foreign (prompt)*: Thursday, £38 15s.; Friday, £38 5s.; Monday, £37 15s.; Tuesday, £37 5s.; Wednesday, £37 3s. 9d.

Sponge Iron.—Experimental work by the U.S. Bureau of Mines in the production of sponge iron at the Seattle, Wash, experiment station has advanced to the point where it is believed that industrial applications of the process can be safely considered for the production of sponge iron as a metallurgical reagent for the precipitation of copper, lead, and numerous other metals from solution. In the process developed through the co-operation of the Bureau of Mines and the University of Washington, almost any type of iron ore can be used for the production of sponge iron. Experiments at the Seattle station showed that similar results are obtained with magnetite, hard and soft hematite, limonite, and sintered hematite.